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Application of ferroelectric triglycine selenate as alcohol sensor

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Abstract : This is simple and highly sensitive method for the determination and discrimination of alcohols at ppm level. This sensing is based on change in electrical conductivities and capacitance due to chemi-adsorption of alcohols at the surface of triglycine selenate (TGSe) in a small duration of response time. This paper deals with the chemi-adsorption of alcohol vapours and give rise to the gas-solid phase interaction with tri glycine selenate pellet as the function of alcohol vapour concentration in air with its ambient leading to act as an alchol sensor.

Key words : Triglycine selenate (TGSe), ferroelectric sensors, methyl alcohol and ethyl alcohol sensing.

1. Introduction

Ferroelectric materials are non-linear dielectric. They show reversible polarization, high dielectric constant and positive temperature coefficient. Ferroelectric also exhibit electro-optic effect, birefringence phenomenon.. In addition, they show pyroelectric and piezoelectric effects and are being used as transducers.

A large amount of work has been reported in the field of ferroelectrics and related materials for physical and chemical sensors application (Murthy, 1995; Gangal, 1997). The transducer behaviour of ferroelectric PVF_2 and TGS has been reported by Tiwary (1993). TiO_2 has been used for sensing hydrogen, oxygen combustional fuels and humidity (Schreibanm et al., 1991; Yulong et al., 1993; Tein et al., 1975; Jain et al., 1997) while SnO_2 has been successfully used for sensing humidity by Roy et al. (1982).

Being ferroelectric, both triglycine sulphate and triglycine selenate have important application in TANDEL (Temperature auto stabilizing nonlinear dielectric element) (Murthy, 1995; Gangal, 1997). These materials were used for building miniature thermostat for controlling the temperature accurately at the operating temperature near its Curie point (T_c). Both triglycine selenate and triglycine sulphate are popular ferroelectric material for the detection of pyroelectric effect and they are useful for memory applications (Tiwari, 1993). Sao (1983) mentioned the moisture sensitive behaviour of triglyci ne sulphate. Tiwáry et al. (2000) have reported the sensor application for sensing aniline.

The presence of glycine molecule with hydrogen bonding leads to the change in positive induction effect, this positive induction effect changes the density of association of oxygen atoms giving rise to the change in conductivity as well as the capacitance (Sharma, 1992). Triglycine selenate has not been, so far reported as a chemical sensor.

Triglycine selenate was found to be offering good stability in thermal and chemical environment. The reversible redox property and cycle stability of triglycine selenate makes it a useful active component for sensor application. By exercising the chemically controlled properties of triglycine selenate, it was used for monitoring the alcohol vapours present in air with its ambient at the ppm level.

This paper deals with chemi-adsorption of alcohol vapours and give rise to the gas-solid phase interaction. Thus its chemisensor behaviour was used for monitoring the alcohols at ppm levels and for differentiating between alcohols.

2. Experimental

2.1. Apparatus

The conductivity and capacitance of the sensor samples have been measured by the Wayne-Kerr auto balance bridge B642 AF, operating at a constant frequency of 1591.5 Hz($\omega=10^4$ rad/sec). The precise variation in temperature have been measured by using Chromel Alumel thermocouple and ECIL electrometer amplifier EAB14 (Electronic Corp., India) and voltmeter of lowest range HIL2301 (HIL India). The thermocouple has a least count of 0.5°C.

An indigenously buit vacuum chamber and sample holder fabricated at our University Scientific Instrumentation Center (USIC) is shown in fig. 1 was used. The sample holder has a heating arrangement with an external arrangement to change the magnitudes of current for changing the temperature at a precision level of 1°C for observing the minute changes. The vacuum chamber with a 12 inches Corning glass cylinder acts as a chamber with 'L' gasket, silica grease was applied on the 'L' gasket to maintain the high degree of vacuum and preventing the leakage of experimental gas from the chamber. This chamber has three pairs of electrodes for connecting heater source, thermocouple and the electrodes of the sensor sample.

The thickness of Triglycine selenate pellet was measured through the Becker-Mercer gauge type C-16 (Motorola Co., Japan) with the least count of 1 μm.

2.2. Procedure

The transparent crystals of Triglycine selenate with good morphology were grown separately at room temperature by slow evaporation from aqueous solutiong of pH 4.0 containing stoichiometric proportion of AR grade glycine and selenic Acid. This glycine was gradually dissolved in dilute selenic acid. The evaporated crystals were cleaved. The triglycine selenate crystals so grown were powdered to the size of 55 μm. and pelletized by applying the pressure of ~1.5 tonnes/cm^2. The pellet surface were further smoothened and coated with fast drying silver paint of resistance 0.05 Ω/cm^2 for making electrical contacts/ electrodes.

3. Results and discussions

1. Vibrational spectroscopic studies confirmed the presence of glycine and selenate in the pellet throught the peaks at 2050, 1600, 1400, 1500, 1200, 1000,600 and 400 cm^{-1} fig. 1(a).

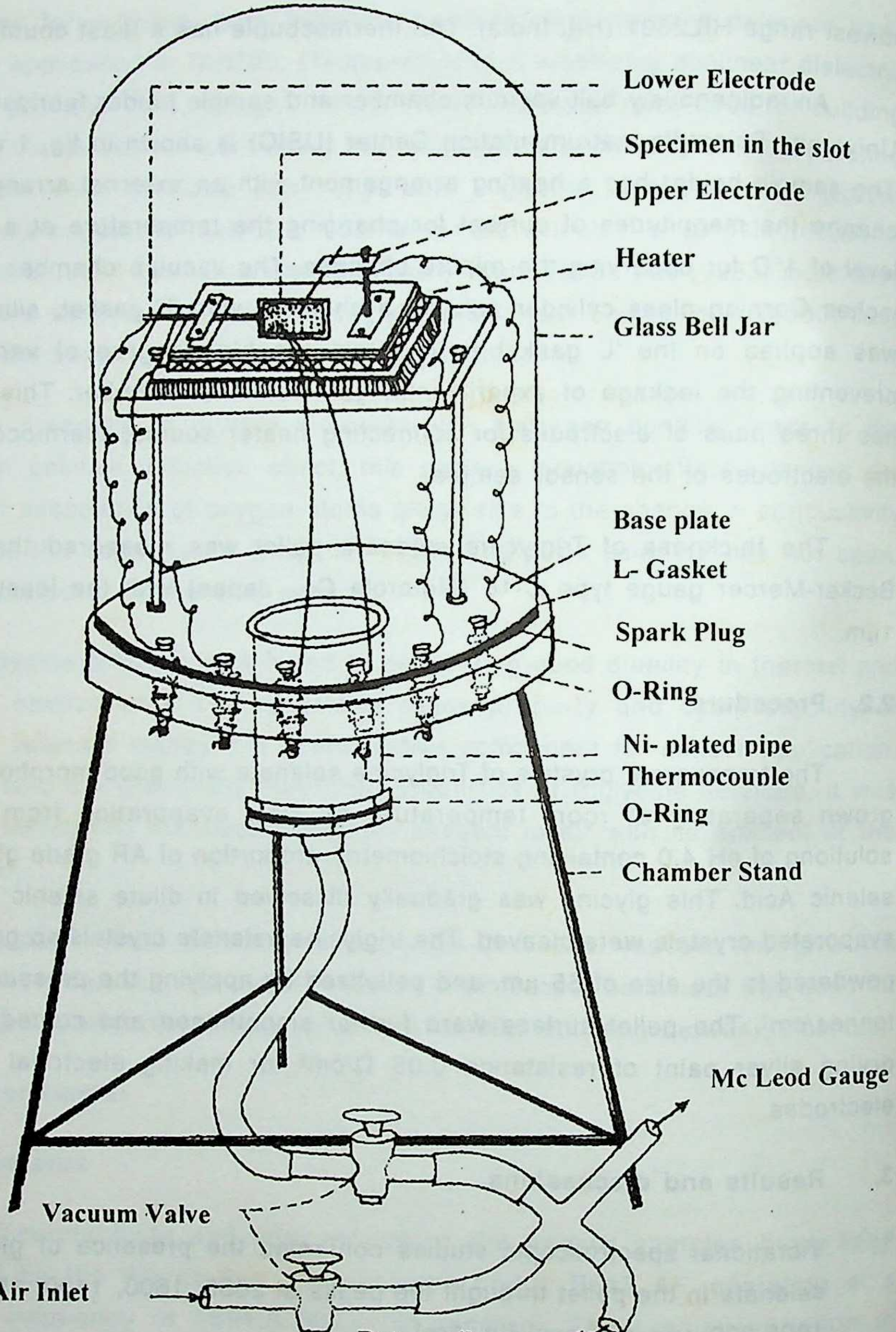

Lower Electrode
Specimen in the slot
Upper Electrode
Heater
Glass Bell Jar
Base plate
L- Gasket
Spark Plug
O-Ring
Ni- plated pipe
Thermocouple
O-Ring
Chamber Stand
Mc Leod Gauge
Vacuum Valve
Air Inlet
Rotary oil pump

Fig 1. Vacuum Chamber.

2. In the presence of alcohol vapours, the absorption peaks were seen at 1000 cm^{-1}, which was stronger and broader to show the presence of alcohol ions.

3. The XRD study of TGSe shown in fig. 2 confirms the P_{21} space group crystalline structure of TGSe.

4. The experiment was performed with in the temperature range of 30-34°C with in the humidity range of 50-54%.

5. The thickness of the TGSe pellet used ethyl and methyl alcohol sensor studies was of thickness 1.8 mm and area 1.13 cm^2.

6. The conductivity and capacitance measurement were carried out and graph between capacitance and concentration was plotted.

Methyl alcohol

The methyl alcohol sensing was performed for various concentrations, i.e. 2 ppm, 5 ppm, 10 ppm, 28 ppm and 40 ppm. The response time increased from 5.2 s to 7.8 s and the recovery time increased from 78 s to 248 s as the concentration of vapours in air was increased. These variations are shown in fig. 3. The recovery time confirms the reusability of TGSe pellet for methyl alcohol sensing. The small response time show the sensitivity of TGSe towards methyl alcohol vapours. The measurement was repeated and results were found reproducible which confirms the stability of TGSe towards methyl alcohol sensing.

Under the influence of methyl alcohol vapours in air, the conductance increased from 9.2 ms a.c. conductance to 11.6 ms. The fig. 4 shows the change in ΔG with respect to the change in the concentration of methyl alcohol vapours. Here, the change in linear and the slopes of the curve shows that the TGSe molecules are quite sensitive towards the methyl alcohol vapours. Fig. 5 shows the change in capacitance i.e. ΔC v/s concentration of methyl alcohol vapours in air.

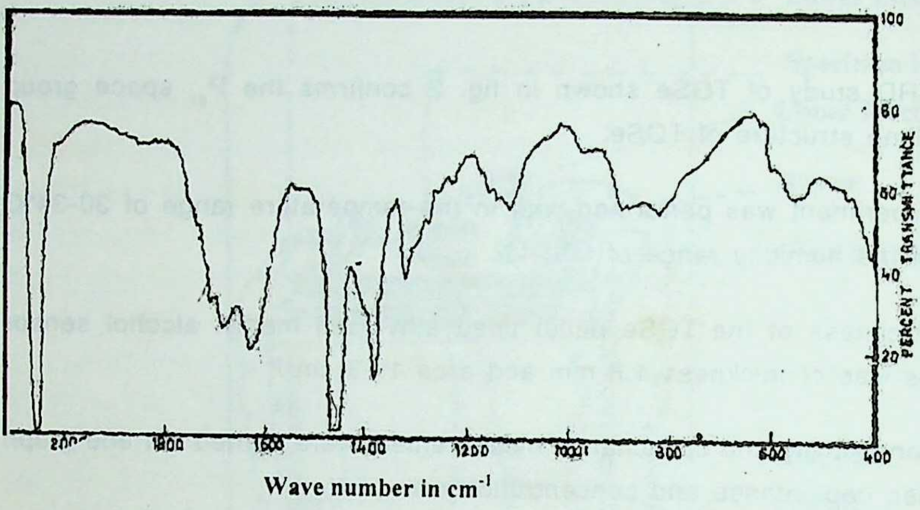


Fig.1 (a) IR spectra of TGSe

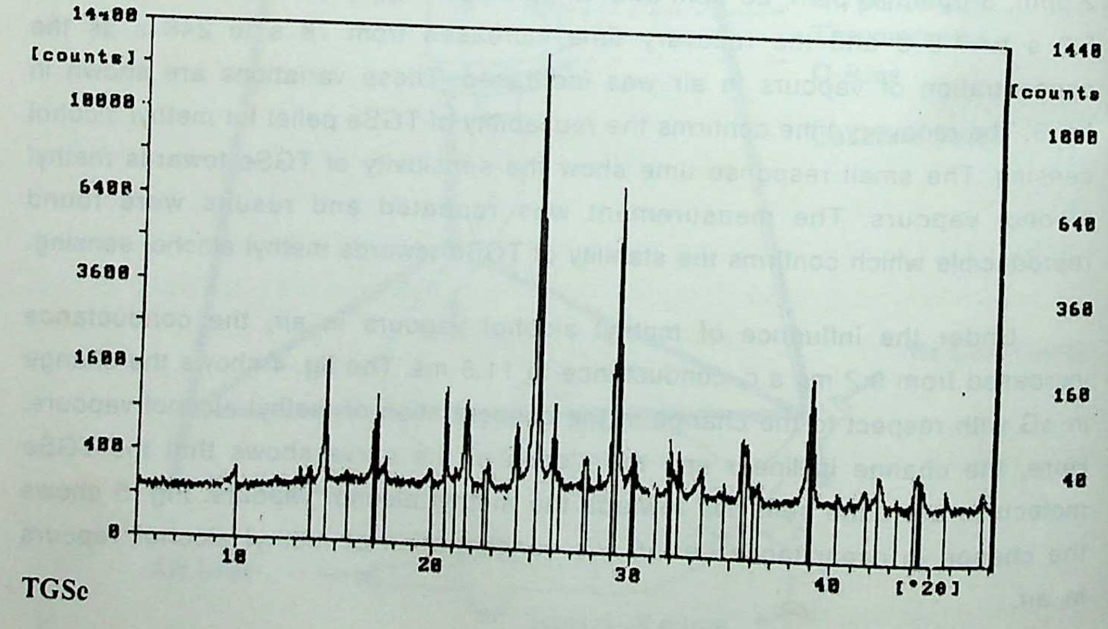


Fig. 2 XRD of TGSe

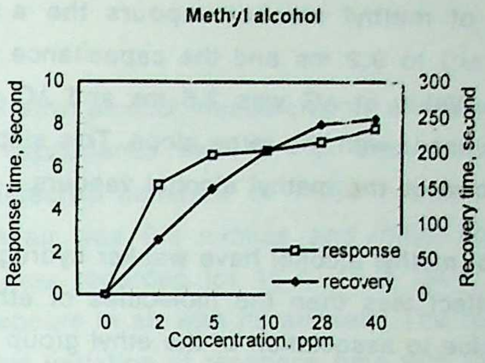


Fig. 3 Plot for response time and recovery time v/s concentration in methyl alcohol

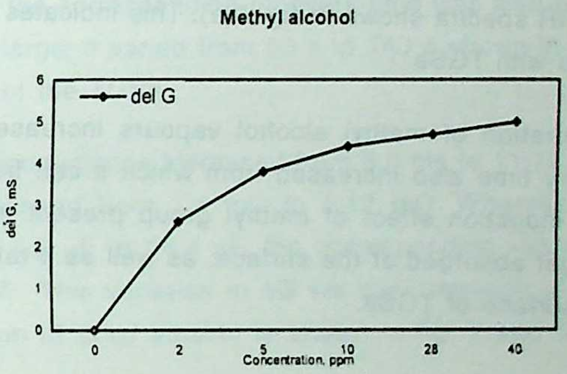


Fig. 4 Plot for ΔG v/s concentration in methyl alcohol

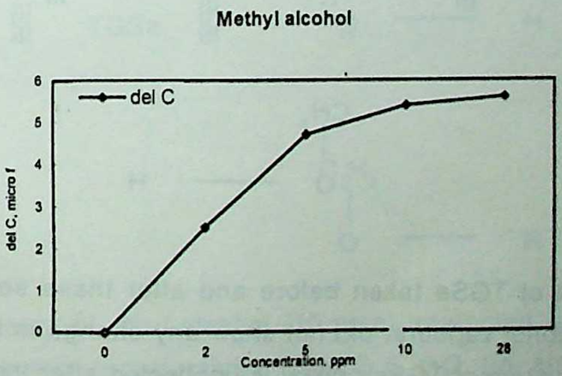


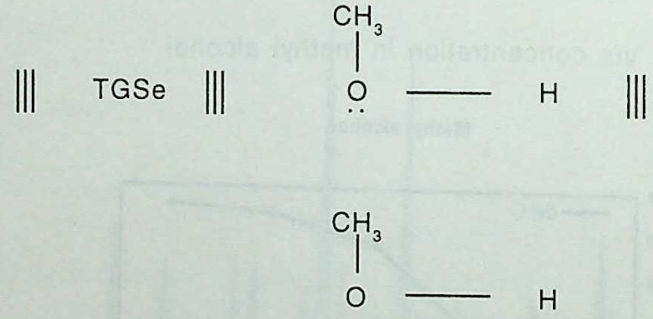
Fig. 5 Plot for ΔC v/s concentration in methyl alcohol

Under the influence of methyl alcohol vapours the a.c. conductivity increased from 6.6 ms (in air) to 9.2 ms and the capacitance increased from 5.6 μf to 9.1 μf for 2 ppm. Value of ΔG was 2.6 ms and ΔC was 2.5 μf. The variation of ΔG and ΔC are linear with the large slope. This slope indicates the sensitivity of TGSe pellet towards the methyl alcohol vapours.

Since the molecules of methyl alcohol have weaker hydrogen bonding and shows positive induction effect less than the molecules of ethyl alcohol. The electron density increased due to association of the ethyl group with TGSe, this increased association increases the value of σ and C.

A broad band at 3400 cm^{-1} and sharp peaks at 3000, 2750 and 1100 cm^{-1} was observed in the IR spectra shown in fig. 1(a). This indicates the presence of OH and methyl group with TGSe.

As the concentration of methyl alcohol vapours increased the response time and the recovery time also increased from which it can be concluded that due to the positive induction effect of methyl group present in methyl alcohol takes more time to get absorbed at the surface, as well as it takes more time to get freed from the surface of TGSe.



$$||| \; \text{TGSe} \; ||| \; \overset{\displaystyle CH_3}{\underset{\cdot\cdot}{O}} - H \; |||$$

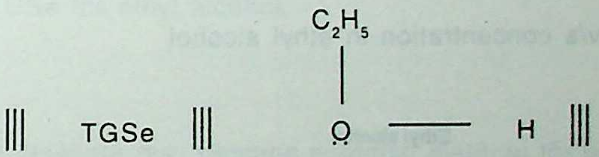
$$\overset{\displaystyle CH_3}{O} - H$$

The XRD report of TGSe taken before and after these sensor studies of TGSe towards the alcohol vapours, did not show any change in the peak, which concludes that the structure of TGSe crystal is unaffected after the alcohol sensor studies.

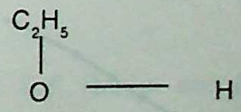
Ethyl alcohol

In case of ethyl alcohol measurements of capacitance shows that the value equivalent air capacitance was 16.4 μf and equivalent air conductance was 12 μΩ. The dielectric constant of TGSe comes out to be 342. The intitial conductance in air was 6.6 mmhos and initial capacitance was 5.6 μf. The response time was recorded for 10.8, 15.3, 20.4, 43.4, 64 and 65.7 ppm of ethyl alcohol vapours in air with its ambient. The response time increased from 5.6 to 9.7 s. This variation of response time with the changing concentration of ethyl alcohol vapours is shown in fig. 3. After the completion of these studies, air was introduced and the initial conductance and capacitance were obtained. Simultaneously the corresponding recovery time was also recorded. The recovery time was quite large; it varied from 50 s to 140 s shown in fig. 6, thus confirming the reusability of the TGSe.

The a.c. conductance increased from 8.0 ms to 11.72 ms the corresponding value of Δσ changed from 1.4 mΩ to 5.12 mΩ. Whereas the C (capacitance) increased from 7.8 μF to 14.4 μF, the corresponding value of μc changed from 2.2 μF to 8.2 μF.. This variation in ΔG v/s concentration of ethyl alcohol and ΔC v/s concentration of ethyl alcohol is shown in fig. 7 and fig. 8, respectively.



$$||| \;\text{TGSe}\; ||| \quad \overset{\text{C}_2\text{H}_5}{\overset{|}{\text{O}}} - \text{H} \;|||$$



$$\overset{\text{C}_2\text{H}_5}{\overset{|}{\text{O}}} - \text{H}$$

The vapours of ethyl alcohol (10 ppm) interacted with the TGSe pellet and increased the a.c. conductivity from 6.6 mΩ (in air) to 8.8 mΩ and the capacitance from 5.6 μF to 7.8 μF. Since the ethyl alcohol vapours has weaker hydrogen bonding and show more positive induction effect as mentioned by

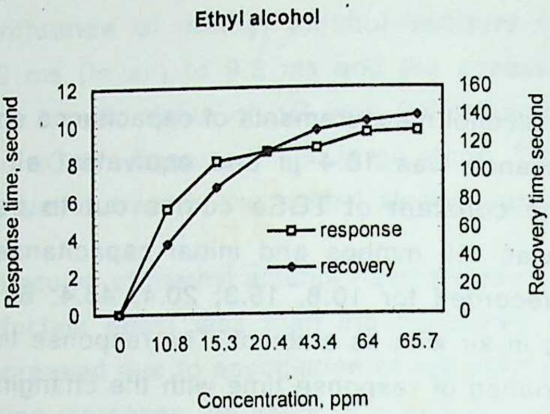


Fig. 6 Plot for response time and recovery time v/s concentration in ethyl alcohol.

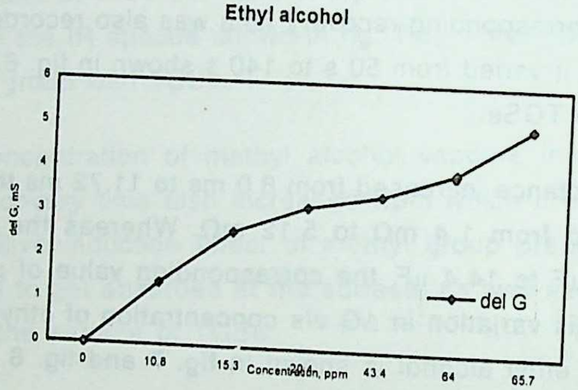


Fig. 7 Plot for ΔG v/s concentration in ethyl alcohol

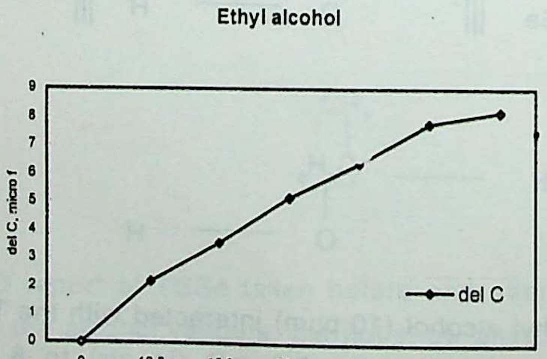


Fig. 8 Plot for ΔC v/s concentration in ethyl alcohol

Sharma (1992), which increases the electron density, thus there is an increase in the association of ethyl groups.

This increase in the association increased the σ and C, the presence of OH group and ethyl group with the TGSe molecule was confirmed by observing the peaks at 3300, 2990 and 2910 cm^{-1} in the IR spectra.

As the concentration of ethyl alcohol vapours was increased response time and the recovery time also increased. These activities were in accordance to the above discussion. As the number of ethyl alcohol molecules increased, the association of these molecules with TGSe increased and for which it took more time (response time) fig. 6, this increased association also increased the change in a. c. conductivity and the change in capacitance shown in fig. 7 and fig. 8, respectively. The XRD of TGSe taken before the sensing activity fig. 2 and after the sensing activities were the same, which confirm that the alcohol molecules did not disturb the crystal structure and were temporarily associated with the TGSe molecules. As the air was introduced inside the chamber, the concentration of air increased, as a result the molecules of ethyl alcohol were freed from the surface of TGSe and initial conductivity was attained. The time recorded as the function of alcohol concentration for this activity was the recovery time which is shown in fig. 6. Thus fig. 3 also confirms the sensitivity and selectivity of TGSe for ethyl alcohol.

Conclusion

Triglycine selenate may become potential material for producing useful and viable ferroelectric chemical sensors.

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References

Gangal, G.A., Sensor 4, NSPTS-4, **1**, 1-16, 1997.

Glance, A., Dvorak, V., Janovec, V. and Rechziegel, E., Phys. Letters, **7**, 106, 1963.

Glance, G., Marlek, Z., Stargblovary, J., Mastner, J. and Novak, M., Appl. Phys., **35**, 1970, 1964.

Jain, M.K., Bhatnagar, M.C. and Sharma, J.L., Sensor 4, NSPTS-4, C44-1, 1997.

Murthy, D.V.S., Transducers and Instrumentation, Prentice Hall of India, New Delhi, 10, 1995.

Marlek, Z., Stargblovay, J., Mastner, J., Moravec, F. and Nocotny, J., Phys. Letters, **13**, 273, 1964.

Putley, E.H., Watton, R., Wreathall, W.M. and Savage, S.D., Advanced Electro Physics, Acad. Press NY, 32, 1972.

Roay, S. and Morissior, S., Sensors and Actuators B, **2**, 329, 1982.

Sao, F. R. Ph.D. thesis, Pt. Ravishankar Shukla University, Raipur, 66, 1963.

Schreibanm, K.D., Kkiermer, U., Geizer, J.F. and Gopel, W., Sensors and Actuators B, **4**, 264, 1991

Sharma, Y.R., Elementary Organic Spectroscopy, S. Chand and Co., New Delhi, 81, 1992.

Tein, T. Y., Stazier, H.L., Gibbon, E.F. and Zacmanidia, D.J., American Ceramics Soc. Bull., **54**, 280, 1975.

Tiwari, G.K,. Ph.D. thesis, Pt. Ravishankar Shukla University, Raipur, 199, 1983.

Tiwary, H.V., Sensor 4, NSPTS-4, **14**, 1-5, 1993.

Tiwary, H. V., Tiwari, G. K. and Naidu, Vasant, XI NFDC Conference, Jammu, 2000.

Yulong, Xy, Yao, Kui, zhou, Xisohua and Cao, Quanzi, Sensors and Actuators B, **14**, 192,1993.

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Groundwater potential of the Kulhan nala basin of Raipur District (C.G.)

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Ms : Received : 24/7/2002, Revised : 12/8/2002, Accepted : 28/9/2002

Abstract : The blockwise groundwater potential of the study area has been estimated using the methodology recommended by G.E.C. The annual recharge and draft in the basin has been worked out to 213.79 MCM and 55.8 MCM respectively, which offers 157.99 MCM for future utilisation. The stage of development with reference to the year 1995 were determined for 2010 AD and 2015 AD. The study area reveals that 99.54 MCM and 80.17 MCM are available as groundwater balance for 2010 AD and 2015 AD respectiviely. This signifies that the Kulhan Nala is capable of supplying sufficient amount of groundwater for various purposes for another 15 years.

1. Introduction

The Kulhan nala basin, lying to the eastern part of Raipur town, is spread over an area of 992.09 sq.km. The study area is included in parts of the four blocks of Raipur district, namely Abhanpur, Arang, Dharsiwa and Tilda. (Fig. 1)

In order to embark upon a planned development and effective management of groundwater resources, it becomes but essential to have an idea of available groundwater potential. The evaluation of groundwater potential involves estimation of natural and artificial recharge to the groundwater from different sources and resultant charges in its storage.

Annual replenishment of groundwater (Natural Recharge)

Rainfall is the principal source of recharge to the groundwater body. Besides rainfall canals, streams, ponds, springs etc. also play an important role in improving groundwater level. The annual groundwater recharge is a sum total of monsoonal recharge and non-monsoonal recharge. Geographical area, infiltration index and specific yields are the governing parameters to determine

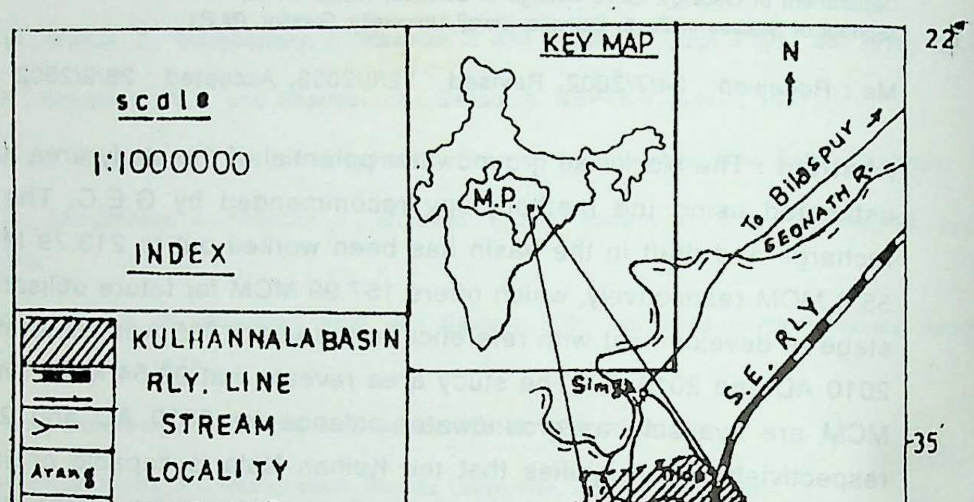
KEY MAP
N
scale
1:1000000
INDEX
KULHANNALA BASIN
RLY. LINE
STREAM
Arang
LOCALITY
METALLED ROAD
RESERVOIR
M.P.
To Bilaspur
SEONATH R.
S.E. RLY
Simga
Kharun R.
Dhariswa
Kharora
Arang
RAIPUR
MAHANADI MAIN CANAL
Abhanpur
Degree sheet No.64G
G/10
G/14
G/11
G/15
G/12
G/16
35'
30'
15'
21°
35'
45'
82 0'
Index to sheet
22°
35'
30'
15'
21°
81°
30'
35'
45'
82°

Fig. : 1 LOCATION MAP OF STUDY AREA

the availability of groundwater in an aquifer (Karanth, 1990). The estimation of groundwater recharge has been done as per the recommendation of GEC, blockwise both by (I) water level fluctuation method and (2) Rainfall infiltration method.

Based on ARDC norms, groundwater recharge has been calculated assuming 3% as specific yield and 10% as infiltration index for water level fluctuation method and rainfall infiltration method respectively for hard rock.

1.1. Monsoon Recharge:

Annual replenishment to groundwater during monsoon period, has been worked out on the basis of following equation.

Monsoon Recharge = (S+Dw) - (Rs+Ris+Rigw)x NF + (Rs+Ris)

Where S = water level fluctuation

Dw = Draft of groundwater during monsoon

Rs = recharge from canal seepage during monsoon

Ris = return flow from subsurface water flow from tanks/ reservoirs during monsoon.

Rigw = return flow from irrigated field during monsoon.

Average rainfall during monsoon for preceeding five years

NF=Normalisation factor of rainfall, which is calculated as

$$NF = \frac{\text{Normal rainfall of a year}}{\text{Average rainfall during monsoon for preceding five years}}$$

1.1.1.Recharge due to annual Water level fluctuation (S):

The value of S is estimated by multiplying area with the specific yield of its hydrogeological unit and then by the observed fluctuation of groundwater level that has taken place in the pre and post-monsoon period (Table - 1.1)

Table 1.1 Blockwise change in groundwater storage

S.No.	Block	Area (Sq. km.)	Av. Fluctuation (m)	Sp. Yield	Change in storage (MCM)
1.	Abhanpur	194.25	4.04	0.03	23.54
2.	Arang	292.18	5.30	0.03	46.45
3.	Dharsiwa	163.8	7.44	0.03	36.56
4.	Tilda	341.79	7.52	0.03	77.11
	Total	992.09	6.075 (average)		183.66

1.1.2. Recharge from canal seepage (Rs):

This component is estimated by multiplying the value of total wetted perimeter, wetted area, number of canal running days and seepage factor i.e. 20 HM per day per million square meter of wetted perimeter. Blockwise computation of these perimeter and estimated volume of seepage water is added as recharge input to groundwater is presented in Table 1.2.

Table 1.2 Blockwise recharge from canal seepage

S.No.	Block	Length of canal	Av. wetted perimeter(m)	Wetted area (sq.m)	No. of running days	Seepage factor ham/ day/10 sq.m of wetted area	Seepage (MCM) (Rs)
1.	Abhanpur	192000	13.41	2574720.0	90	20	46.34
2.	Arang	36010	9.47	341014.7	90	20	6.13
3.	Dharsiwa	62010	7.75	480500.0	90	20	8.65
4.	Tilda	51430	5.08	261264.4	90	20	4.70
	Total recharge (MCM)						65.82

1.1.3 Seepage from tanks/reservoirs (Ris)

The existing number of tanks and ponds used for irrigation purposes have been taken into account and by assuming a percolation seepage from beneath the bed of such structures @ 60 cm per annum per unit area of the total water spread area, an estimation of volume of water joining the groundwater body each year in each block has been carried out (Table - 1.3)

Table 1.3 Seepage from surface reservoirs

S.No.	Block	No. of tanks/ponds	Total water spread area (hac)	Seepage factor (m/year)	Total seepage (MCM)
1.	Abhanpur	5	131	0.60	0.786
2.	Arang	3	1772	0.60	10.63
3.	Dharsiwa	3	39.8	0.60	0.24
4.	Tilda	7	188	0.60	1.128
	Total	18			12.784

1.1.4. Return seepage from irrigated field (Rigw) :

Application of surface water irrigation to the crops in the field area during monsoon period is basically as protective irrigation in nature. Assuming 805 efficiency of irrigation application to the crops, the water that does not get utilised by the crops and returns to groundwater reservoir lying beneath each irrigated field is calculated (Table - 1.4)

Table - 1.4 : Blockwise seepage from irrigated fields

S.No.	Block	Area irrigated (ha)	Av. Depth of water applied (m)	Irrigation water applied (ham)	water delivered at outlet 80% efficieney (ham)	seepage factor	seepage (MCM)
1.	Abhanpur	3490.33	0.35	1221.61	1527.01	0.40	6.10
2.	Arang	5249.96	0.35	1837.48	2296.85	0.40	9.18
3.	Dharsiwa	2943.20	0.35	1030.12	1287.65	0.40	5.15
4.	Tilda	6141.37	0.35	2149.47	2686.83	0.40	10.74
	Total	17824.86		6238.68	7798.34		31.17

Various components of monsoon recharge and their respective volumes has been computed blockwise (Table 1.5)

Table - 1.5 : Total monsoon recharge

S.No.	Block	S	Dw	Rs	Ris	Rigw	NF	Monsoon Recharge (MCM)
1.	Abhanpur	23.54	10.71	46.34	0.786	6.10	1.097	26.31
2.	Arang	46.45	12.65	6.13	10.63	9.18	1.408	63.44
3.	Dharsiwa	36.56	23.14	8.65	0.24	5.15	1.395	72.58
4.	Tilda	77.11	9.7	4.7	1.128	10.74	1.404	85.06
	Total							247.39

1.2. Non-monsoon recharge :

Rainfall also takes place between October to May each year. Thus by applying rainfall infiltration index to each block area, quantity of recharge during non-monsoon period has been computed (Table - 1.6)

Table - 1.6 : Blockwise non-monsoon recharge

S.No.	Block	Area (sq.km.)	Winter rainfall (mm)	Rainfall infiltration index	Non-monsoon recharge (MCM)
1.	Abhanpur	194.25	33.0	0.1	0.64
2.	Arang	292.18	37.6	0.1	1.09
3.	Dharsiwa	163.8	33.5	0.1	0.54
4.	Tilda	341.79	55.0	0.1	1.88
	Total				4.15

Annual recharge and utilisable resources :

The annual groundwater recharge is a sum total of monsoon and non-monsoon recharge. Out of this total recharge volume, 15% amount is separated out towards allocation for drinking and industnal requirements. Balance 85% of total recharge volume is accounted as utilisable groudwater resource (Table - 1.7)

Table 1.7: Blockwise annual recharge and utilisable resources

S.No.	Block	Monsoon recharge (MCM)	Non-monsoon recharge (MCM)	Total annual recharge (MCM)	Utilisable resorces (MCM)
1.	Abhanpur	26.31	0.64	26.95	22.90
2.	Arang	63.44	1.09	64.53	54.85
3.	Dharsiwa	72.58	0.54	73.12	62.15
4.	Tilda	85.06	1.88	86.94	73.89
	Total	247.39	4.15	251.54	213.79

1.3. Annual groundwater draft :

Groundwater extraction takes place through structures like dugwells with mhots/persian wheel or fitted with pumps, dug-cum bore wells, shallow tube wells etc. As per the random field sampling, the unit draft of groundwater caused by such units has been assumed as @ 0.005 MCM per dugwell with mhot/persian wheel per year, @ 0.01 MCM per dug well fitted with pump per year, and @ 0.068 MCM per shallow tube well per year. The computation of annual groundwater draft is done by multiplication of assumed unit draft mentioned above with corresponding number of wells in each category. The blockwise net annual draft is estimated as 70% of the gross annual groundwater draft of the corresponding block (Table - 1.8).

Table - 1.8 : Blockwise groundwater draft

S.No.	Block	Groundwater structure			Annual Groundwater Draft (MCM) per unit Groundwater structure				Net Annual Groundwater draft (MCM)
		A	B	C	A	B	C	Total	
1.	Abhanpur	1970	492	8	9.85	4.92	0.54	15.31	10.71
2.	Arang	2690	415	7	13.45	4.15	0.47	18.07	12.65
3.	Dharsiwa	2820	1080	120	14.1	10.8	8.16	33.06	23.14
4.	Tilda	1850	385	11	9.55	3.85	0.75	13.29	9.70
	Total							80.29	56.20

Note : A = dugwells fitted with mhots
B = dugwells fitted with pumps
C = Tubewells (shallow)

1.4. Groundwater balance :

The groundwater balance available for future use has been computed by deducting the net annual groundwater draft from the utilisable groundwater resource (Table-1.9)

Tabel - 1.9 : Blockwise groundwater balance

S.No.	Block	Utilisable resource (MCM)	Groundwater draft (MCM)	Groundwater Balance (MCM) in 1994-95
1.	Abhanpur	22.90	10.71	12.19
2.	Arang	54.85	12.65	42.2
3.	Dharsiwa	62.15	23.14	39.01
4.	Tilda	73.89	9.70	64.19
	Total	213.79	56.20	157.59

1.5. Future groundwater development :

It is a well known fact that water has a decisive role to play in every aspect of our existence. It is such a natural resource whose scarcity can usher disastrous conspequence as it has no substitute being the first reason and secondly its quantity in the hydrologic cycle remain fairly fixed. The area under investigation is slowly transgressing from agricultural civilisation to industrial civilisation, the need for water has increased manifold. Water today in this region also is being looked as one of the economic commodities, this vision of water resource in turn demands management skill, as well as evaluation of its potential both in space and time. For the planned civilisation of groundwater resource the first requisite is the approximate estimate of the available resource, annual groundwater draft and groundwater balance etc. (Taleye et al., 1990).

Keeping in view of the future requirements it had been possible to lay down a programme of groundwater development for 2000 AD and 2025 AD respectively for the Kulhan nala basin. The present stage of groundwater development (1995) as well as for 2000 AD and 2025 AD in respect of draft is presented blockwise in Table - 1.10. The level of groundwater development at any reference year (1995) is the ratio between annual net groundwater draft (in MCM) and utilisable groundwater balance in that year (in MCM) and it is expressed in percentage.

Table - 1.10 Blockwise stage of development

S.No.	Block	Stage of Development		Year 2010 AD	Draft (MCM)	Year 2015 AD	Draft (MCM)
		Level of G.W development in % in 1995	Yearly rate of G.W.development				
1.	Abhanpur	46.76	0.80	58.76	13.45	62.76	14.37
2.	Arang	23.06	1.30	42.56	23.34	49.06	26.90
3.	Dharsiwa	37.23	3.60	91.23	56.69	109.23	67.88
4.	Tilda	13.12	1.00	28.12	20.77	33.12	24.47
	Total				114.25		133.62

Thus if the present utilisable groundwater balance (213.79 MCM, Table 1.9) assumed to remain the same, the annual draft for the basin in the year 2010 AD and 2015 AD shall be approximately 114.25 and 133.62 MCM respectively.

1.6 Groundwater prospects :

The above study reveals that in respect of utilisable resource (213.79 MCM) the groundwater draft calculated for various purposes (blockwise) amounts to 55.80 MCM, showing 157.59 MCM available as groundwater balance for the year 1995. In Table - 1.11 groundwater balance in respect of groundwater draft for 2010 AD and 2015 AD is shown.

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Table 1.11 : Blockwise groundwater prospects :

S.No.	Block	1995			2010 AD		2015 AD	
		Utilisable resource (MCM)	G.W. draft (MCM)	G.W. balance (MCM)	Draft	Balance	Draft	Balance
1.	Abhanpur	22.90	10.71	12.19	13.45	9.45	14.37	8.53
2.	Arang	54.85	12.65	42.2	23.34	31.51	26.90	27.95
3.	Dharsiwa	65.15	23.14	39.01	56.69	5.46	67.88	-5.73
4.	Tilda	73.89	9.30	64.19	20.77	53.12	24.47	49.42
	Total	213.79	55.80	157.59	114.25	99.54	133.62	80.17

Conclusion :

The critical analysis of Table - 1.11 exhibits that 99.54 MCM and 80.17 MCM is available as groundwater balance for 2010 AD and 2015 AD respectively. At the same time it is easily understood from "Dharsiwa Block" case, where stage of development would be 109.23% in 2015 AD (Table-1.10). It means that draft of nearly 67.88 MCM would be made in 2015 AD against the replenishment of 62.15 MCM. Thus, there will be an overdraft of 5.73 MCM taking out from static storage of water. So to avoid overdraft and damage of aquifer suitable artificial recharge structure is inevitable to overcome this problem. Further, it can be said that the Kulhan nala is capable of supplying sufficient amount of groundwater for various purposes for another 15 years. Hence, there is considerable scope of groundwater development in future.

References

Karanth, K.R., Groundwater Assessment, Development and Management, Tata Megraw Hill Publishing Company Limited, New Delhi, 1990.

Ministry of Irrigation, Report of the groundwater estimation committee-groundwater estimation methodology, Govt. of India, New Delhi, 1984.

Taleye, S.M., Delvi, B.V., Mazumdar, G.K. and Wadatkar. S.B., Computation of Ground water potential and hydrological budgeting in agricultural watersheds - (A case study). Proceedings volume AIS on Modern techniques of Rainwater harvesting water conservation and artificial recharge for drinking water afforestation horticulture and agriculture 19-21st Nov. Pune. pp 91-94, 1990.

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Fixed point theorems on metric spaces with Cantor intersection property

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Abstract : In a convex metric space X having Cantor Intersection property, we prove that a mapping T defined on a close convex nonempty subset A of X into itself satisfying a metric condition, with have a unique fixed point.

Key Words : Convex metric space, Cantor Intersection Property.

AMS (1980) Subject Classification Code : 54 H 25, 47 H 10.

Introduction

Several authors have investigated the existence of fixed points for different classes of mappings defined on closed convex subsets of infinite dimensional Banach space satisfying some metric conditions (e.g.[2],[3].). We know that a metric space X is said to have Cantor Intersection Property if every decreasing sequence $\{A_n\}_{n\in N}$ of nonempty closed subset of X with $\delta(A_n) \longrightarrow 0$ has nonemply intersection. This property is useful tool to obtain fixed point. We therefore, propose to prove fixed point theorems in metric space and then convex metric space as well using CIP with a metric condition as below :-

$$d(Tx,Ty) \leq a\, d(x,y) + b\,[d(x,Tx) + d(y,Ty)] + c\,[d(x,Ty) + d(y,Tx)] +$$

$$e[d(x,T^2x) + d\,(y,T^2x)] + g\,[d(Tx, T^2x) + d(Ty,T^2x)]$$

for all x, y in A, where $0 \leq a,b,c,e,\ g < 1$, $2a + 2b + 3c + 5e + 3g \leq 1$

Preliminaries

Let X be a metric space. A mapping $W : X \times X \times [0,1] \longrightarrow X$ is said to be convex structure on X if for all x,y in X and $\lambda \in [0,1]$ the following condition is satisfied.

$$d(u,W(x,y,\lambda)) \leq \lambda\, d(u,x) + (1-\lambda)\, d(u,y) \text{ for all } u \in x.$$

A metric space with convex structure is called a convex metric space. A subset A of a convex metric space X is said to be convex if

$$W(x,y,\lambda) \in A \text{ for all } x,y \in K \text{ and } \lambda \in [0,1].$$

A metric space X is said to have Cantor Intersection property (CIP) if every decreasing sequence $\{A_n\}_{n \in N}$ of nonempty closed subsets of X with $\delta(A_n) \longrightarrow 0$ has nonempty intersection. In this paper $\delta(A)$, $\overline{A}$ and $\overline{Co}(A)$ denote respectively, the diameter, closure & closed convex hull of a subset A of X.

Lemma 2.1. Let X be a metric space and T: X —> X mapping satisfying the inequality

$$\textbf{(2.1)}\quad d(Tx, Ty) \leq a\, d(x,y) + b\,\{d(x, Tx) + d(y, Ty)\}$$
$$+ c\,\{d(x,Ty) + d(y,Tx)\}$$
$$+ e\,\{d(x,T^2x) + d(y,T^2x)\}$$
$$+ g\,\{d(Tx, T^2x) + d(Ty, T^2x)\}$$

for all $x,y \in X$, where $0 \leq a,b,c,e,g < 1$ with $2a+2b+3c+5e+3g \leq 1$.

Then,

(i) $d(T^n x, T^{n+1}x) \leq d(t^{n-1}x, t^n x)$, for all $n \varepsilon N$

(ii) $$d(Tx, Ty) \leq \left[\frac{a + b + c + 3e + 2g}{1 - a - 2c - e - g}\right] \{d(x,Tx) + d(y, Ty)\}$$

Proof.

(i) Using inequality (2.1) we have,

$$d(T^n x, T^{n+1}x) \leq \left[\frac{a + b + c + e}{1 - b - c - 2e - g}\right] d(T^{n-1}x, T^n x) \leq d(T^{n-1}x, T^n x)$$

(ii) Using inequality (2.1) and Lemma 2.1 (i) we have,

$$d(Tx, Ty) \leq \left[\frac{a + b + c + 3e + 2g}{1 - a - 2c - e - g}\right] \{d(x,Tx) + d(y, Ty)\}$$

Now we prove our main results :

Theorem 3.1 Let X be a metric space having CIP and T:X -----> X a mapping satisfying the inequality (2.1), then the following conditions are equivalent

(a) T has a unique fixed point in X.

(b) $\inf \{d(x, Tx) : x \in X\} = 0$

Proof. If (a) holds then (b) is obvious. To show that (b) implies (a), it is sufficient to prove that the set $\{d(x,Tx) : x \in X\}$ has a smallest element.

Consider the following system of sets

$$An = \left[x \in X : d(x,Tx) \leq \frac{1 - a - 2c - e - g}{2n(1 + b - c + 2e + g)} \right]$$

Where $n \in N$. Since $\dfrac{1 - a - 2c - e - g}{2n(1 + b - c + 2e + g)} > 0$, by definition of infimum there exists some x_0 in X such that

$$d(x_0,Tx_0) < \frac{1 - a - 2c - e - g}{2n(1 + b - c + 2e + g)}$$

This implies that A_n is nonempty. Using lemma 2.1 (ii) we have for all $x,y \in A_n$

$$d(Tx,\ Ty) \le \left[\frac{a + b + c + 3e + 2g}{1 - a - 2c - e - g}\right]\{d(x,Tx) + d(y,\ Ty)\}$$

therefore, for all x, y $\in$ An, we have

$$d(Tx,\ Ty) \le \left[\frac{a + b + c + 3e + 2g}{1 + b - c + 2e + g}\right]\left[\frac{1}{n}\right] \le \frac{1}{n}$$

Now, for all x, y $\in A_n$, we have

$$d(x,\ y) \le d(x,Tx) + d(Tx,\ Ty) + d(Ty,y)$$

Using Lemma 2.1(ii) for any x, y $\in A_n$, we have

$$d(x,\ y) \le \left[\frac{1 + b - c + 2e + g}{1 - a - 2c - e - g}\right]\{d(x,Tx) + d(y,Ty)\} \le \frac{1}{n}$$

It means $\delta(A_n) \le 1/n$, $\delta(TA_n) \le 1/n$ and therefore, we have $\delta(\overline{TA}_n) \le 1/n$, Lemma 2.1(ii) implies that $TA_n \subset A_n$. Therefore $(\overline{TA}_n)$ is a decreasing sequence of closed nonempty sets with $\delta(\overline{TA}_n) \longrightarrow 0$.

Since X has CIP therefore the sequece $(\overline{TA}_n)$ has nonempty intersection It only remains to show that $(\overline{TA}_n) \subseteq A_n$ for each $n \in N$. Suppose that $v \in \overline{TA}_n$. Then there exists a sequennce $\{z_n\}$ in TA_n such that $z_m \longrightarrow v$. Obviously $z_m = Ty_m$, where $y_m \in A_n$ and $d(v,Tv) \le d(v,z_m) + d(Ty_m,\ Tv)$.
using inequality (2.1) and Lemma 2.1(i), we have

$$d(v,Tv) \le \left[\frac{1+a+2c+e+g}{1 - b - c - g}\right] d(v,z_m) + \left[\frac{a+b+c+3e+2g}{1-b-c-g}\right] d(y_m,\ Ty_m)$$

i.e.

$$d(v,Tv) \leq \left[\frac{1+a+2c+e+g}{1-b-c-g}\right] d(v,z_m) + \left[\frac{1-a-2c-e-g}{2n\,(1+b-c+2e+g)}\right] d(y_m, Ty_m)$$

Letting m tends to infinity ,we have

$$d(v,Tv) \leq \left[\frac{1-a-2c-e-g}{2n\,(1+b-c+2e+g)}\right] \text{ and } v \in A_n.$$

Therefore $\overline{TA}_n \subset A_n$. The sequence $\{A_n\}$ is a decreasing sequence of nonempty closed sets such that $\delta(A_n) \dashrightarrow 0$.
This completes the proof of Theorem.

Theorem 3.2 Let T be a mappinng of nonempty closed convex subset A of a convex metric space X having CIP, into itself. If T satisfies the inequality (2.1). Then T has a unique fixed point in A.

Proof. Let us assume that,

$$\inf\{d(x,Tx) : x \in A\} = \eta > 0,$$

then for every $\epsilon > 0$, there exists some $x \in A$ such that

$$d(x,Tx) , \eta + \epsilon.$$

Since k is convex therefore

$$z = W(T^2x, T^3x, \tfrac{1}{2}) \text{ is in } A.$$

Using definition of convex structure, we have

$$\begin{aligned} d(z,Tz) &= d[w(T^2x,T^3x, \tfrac{1}{2}), Tz\} \\ &\leq \tfrac{1}{2} d(T^2x,Tz) + \tfrac{1}{2} d(T^3x, Tz) \end{aligned}$$

again using inequality (2.1) and Lemma 2.1 (i), we have,

$$d(z,Tz) \leq \left[\frac{2a+b+3c+5e+2g}{2\,(1-b-c-g)}\right] d(x, Tz)$$

$$= \lambda d\,(x, Tx)$$

$$\text{Where, } \lambda = \frac{2a + b + 3c + 5e + 2g}{2\,(1 - b - c - g)} < 1.$$

Choosing $\epsilon < (1-\lambda)/\lambda \,.\, n$ we have

$$d(z, Tz) < n$$

a contradiction, Hence $\inf\{d(x, Tx) : x \in A\}=0$.

And hence by Theorem 1, T has a unique fixed point in A.

This completes the proof.

COROLLARY 1. If we put $e = 0 = g$ in **(2.1)** then **Theroem 3.1** becomes **Theorem 1** of [1] & **Theorem 3.2** becomes **Theorem 3** of [1]

COROLLARY 2. If we put $c=e=g=o$ in **(2.1)** then **Theorem 3.2** becomes **Theorem 2** of [1].

References

Beg, I. and Azam, A., Existence of fixed points of non-linear mappings, J. Nature, Sci. Math., **29** (2), 149-158, 1989.

Browder, F.E., Non expansive non-linear operators in a Banach space, Proc. Mat. Acad. Sci. USA. **54**, 1041-1044, 1965.

Kirk, W.A., A fixed point theorem for mappings which do not increase distance, Amer. Math, Monthly **72**, 1004-1006, 1965.

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Information, education, communication in context of reproductive and child health including HIV/AIDS

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Abstract : 93.52% Males and 87.18% Female reveal that Television is their leading source of information pertaining to R.C.H. activities including H.I.V./AIDS. On further analysis of the collected data it has been noted that there is a wide gap between the knowledge of the people and their practices. Beside other things, the authors suggest (1) every efforts must be made to enrich the knowledge of the people & motivate them to put that scientific knowledge into practices by the wise use of various available medias particularly that of Television, (2) we have to develope a strategy for interaction between the key players i.e. patients, providers of health services and the community with the aim at changing community attitude and behaviour i.e. to awaken the mind to think correctly which will place the three key players at an equal footing and will encourage active participation for open and honest discussion about fears, concerns, pre judices and problems.

Key Words : Democratic Alliance, Key Players, Media Mix

1. Introduction

Each and every human being has an inherent desire to learn and awakening of this desire is the need of the hour. This important responsibility of awakening the desire lies with Information, Education, Communication (I.E.C.). By awakening this desire we will be able to form a democratic alliance between the key players i.e. the patients, the community and the health service providers which is a must for the success of Reproductive and Child Health (R.C.H.) Programme, because till such democratic alliance could not be formed, people will feel shy in exchanging the ideas about their problems which ultimately harm the community as a whole including the providers of the health services. So those engaged in this crucial task of IEC have great responsibilites to reach every one effectively either through direct contact or through other means. By judging the importance of IEC for bringing awareness not only in terms of knowledge but also put that knowledge in to practices, the authors have under taken this study to assess the IEC in RCH including HIV/AIDS.

2.0 Material and method

An objective type of questionaire covering various aspects of IEC in context of RCH was drawn in Hindi. After pretesting suitable modification were done in the questionaire.

The Questionaires thus framed out were distributed among 1310 (834 males and 476 females) respondents selected by rapid sample survey approach between 1st January 2001 and 28th February 2001 of Janta Colony and its adjoining areas in Gudhiyari, Raipur (C.G.) to fill up their views on the subject. The respondents who were illeterate, the questionaire were explained to them and fill up their views bye the interviewers.

3.0 Observation and discussions

Data from 1310 [834 (63.66%) males and 476 (36.33%) females] respondents belonging to 15-45 years of age group were collected and analysed.

Television (T.V.) is the leading source of the Information for both males (93.52%) and females (87.18%) while the peer groups is the next common source of Information (Table-1). 40.84% males and 44.11% females reveal that they have also got information from health personnel i.e. providers of health services.

Bhasin *et al.* (1999) noted in study that T.V. is most important source of getting information regarding HIV/AIDS. Lal (1999) in his editorial revealed that 80.4% of men and women mentioned that their first source of information was T.V./Radio while the health workers i.e. providers of health services were cited as primary source of AIDS awareness only by 21.7% of the respondents. Again Lal *et al.* (1999) in his study reported that over whelming proportion of (91.85) men and women mentioned that first source of information being T.V. The findings of these studies were more or less similar to the findings of the present study.

Table-1

Sources of information pertaining to RCH including HIV/AIDS

Sources N=834	Male N=476	Female
Television 780	(93.52)	415 (87.18)
News Papers/Magazines/Journals	430 (51.55)	244 (51.26)
Peer Groups	562 (67.38)	360 (75.63)
Health Personnel	334 (40.04)	210 (44.11)
Other Sources	203 (24.34)	90 (18.50)

Figures in parenthesis indicate percentage.

Almost all 100% respondents have heard about one or the other method of contraception (Table-2). A higher proportion of males (93.40%) than their females (84.66%) counter parts were familiar with the Oral Pills as contraceptive. Similarily, 64.54% males and 75.63% females knew that Condoms are used as one of the contraceptive method. 63.44% females and 26.53% males have heard about safe period, but majority of both males and females didn't have correct idea of safe period (Table-3). Agarwal *et al.* (2000) in his study among girls found that most well known contraceptive method was oral pills (77.65%) have knowledge about oral pills while 85.1% boys in comparision to 47.3% girls knew about condoms. These findings are more or less in accordance of the findings of the present study.

Table-2

Knowledge about contraceptive methods

Contraceptive Method	Male N=834	Female N=476
Oral Pills	782 (93.40)	403 (84.66)
Condom	540 (64.54)	360 (75.63)
Cu. T.	262 (31.41)	199 (41.60)
Sterilization	403 (48.52)	248 (63.44)
Safe Period	238 (26.53)	302 (63.44)
Others	335 (40.16)	102 (21.42)

Figures in parenthesis indicate percentage.

Table-3

Knowledge about safe period

(One week before and one week after menstruation)

	Correct	Incorrent	Total
Male	41	197	238
N=238	(17.22)	(82.79)	(100.00)
Female	62	240	302
N=302	(20.52)	(79,47)	(100.00)

Figures in parenthesis indicate percentage.

Regarding benefits of contraceptives 64.28% females in comparision to 35.53% males were of the view that it helps in spacing children while 72.50% male in comparision to 58.19% females were of the view that contraceptive are used to control population. Similarily higher percentage of males (55.67%) in comparision to (42.65) females reveals that condom act as safe guard against HIV/AIDS (Table-4).

Table-4

Benefits of contraceptive methods

Benefits	Male N=834	Female N=476
Spacing of Children	298 (35.53)	306 (64.28)
Avoidance of unwanted Pregnancy	114 (13.66)	175 (36.56)
Control Population	603 (72.50)	277 (59.19)
Safe Guard against HIV/AIDS	481 (55.67)	204 (42.65)

Figures in parenthesis indicate percentage.

Regarding knowledge about sterilization operation, 61.29% females in comparision to their 51.61% males counterparts have knowledge that Vasectomy (V.T.) operation is simiple/easy than Tubectomy (T.T.) operation (Table-5). But as per expectation 82.21% male prefer their spouse to undergo sterilization operation in comparision to only 22.36% females (Table-6). It strengthen the idea that males are still of the view that it is the female who undergo surgery on one pretext or the other viz. may become weak, loss of libido and so on.

Table-5

Vasectomy is simple/easy than tabectomy

	Yes	No	Total
Male,	208	195	403
n=403	(51.61)	(48.58)	(100.00)
Female	152	96	248
N=248	(61.29)	(38.50)	100.00)

Figures in parenthesis indicate percentage.

Table-6

Preference of sterilisation operation of self or spouse

	Self	Spouse	Total
Male,	37	171	208
n=208	(17.68)	(82.21)	(100.00)
Female	118	34	152
n=152	(77.63)	22.36)	(100.00)

Figures in parenthesis indicate percentage.

Table-7

Knowledge about safe sex

	Male, N=834	Female, N =476
Use of Condom during sexual intercourse	498 (59.70)	203 (42.64)
Having sexual intercourse faithful partner	630 (75.53)	420 (88.23)
Mutual Masterbation	120 (14.58)	11 (2.31)
Not to share sex Toys, Candle etc.	23 (2.75)	31 (6.51)
Any other information	360 (43.16)	24 (5.04)

Figures in parenthesis indicate percentage.

Knowledge about safe sex : 88.23% females and 75.53% males were of the view that having sexual intercourse with one faithful partner while 42.64% females in comparison to 59.70% males knew that use of condoms during sexual intercourse are the best means of safe sex (Table-7). Agarwal *et al.* (1998, 1999) in his study among medical under graduates noted that 86.54% males in comparison to 92.56% females and 82.45% males in comparison 91.89% females were of the view that using condoms during sex and having sexual relation with one faithful partner respectively helps in prevention of AIDS. Though the proportion of percentage in the study of Agarwal *et al.* (1998, 1999) is higher than that of the present study, the reason seems to be because the present study was carried out among common people while that of Agarwal among medical under graduates.

4.0 Conclusion

From above observation & discussions, the authors reached to the conclusion that though the present efforts are able to bring awareness among the masses about various aspects of R.C.H. but still there is a wide gap between the knowledge and practices of the people which is the matter of real concern. So every effort must be made to bridge this gap i.e. bring the correct knowledge, the people have in to their practices. This is possible among other things by (I) Unearthing the hinderance i.e. by conducting more K.A.P. studies. The findings of these studies will act as pegs on which to hang new knowledge. The various studies conducted by different authors including the present one in different parts of the country from time to time found that most common source of information for the massess about health matter is "TELEVISION" T.V. is an audio visual media and can easily be exploited to reach certain target groups for education and will be more effective if our health education messages will be telecast with a bit entertainment touch. So proper & wise use of media mix i.e. T.V., Radio, Dailies, Periodicals, Cinema, Posters etc. may be helpful in strengthening the IEC campaign for not only enriching the knowledge of the people but also motivate them to bring that scientific knowledge in to their practices (II) By strenthening the democratic alliance between the key players i.e. the patients, people around them and the service providers about health matters. So all these three freely and frankly exchange their views about fears, concerns, prejudices and problems and not only seek help but also extend their help in what ever form, where ever and when ever desired. Sexually Transmitted Diseases (S.T.D.) diagnosis, treatment and education camp is one of the best means for operationalising this strategy. These camps are organized by local people using medico technical services of the health service providers. The community contribute to facilitate these camps by providing venue and volunteers as wel by publicizing the events in the nearby community. In these camps hidden S.T.D cases come forward. This approach also helps to reduce the stigma attached to the disease and in early detection of cases. these camps provide best opportunities for counselling and can be organized at low cost and do not need additional funding.

References

Agarwal, A.K., Mahajan, P.C. and Worwankar, K., J. Ravishankar Univ., **13** B (Science), 40, 2000

Agarwal, A.K., Agarwal, Anjoo and Mahajan, P.C., J. Ravishankar Univ., **11-12**B (Science), 51 1998-99

Bansal, A.K. and Chandorkar, R.K., Tribal Health Bulletine (ICMR) **3** (2),12, 1997.

Bhasin, S.K., Pandit, K., Kannan, A.T. and Dubey. K.K., IJCM: XXIV-4, 167, 1999.

Benjamin, A.I., Panda, P., Shavinder, S. and Bhatia, A.S., IJCM:XXVI-4, 201, 2001.

Bansal, A.K. and Chandorkar, R.K., Tribal Health Bulletin (ICMR) **4**(1), 10, 1998.

Lal, S., IJCM: XXIV, 2-47, 1999.

Lal, S., Vashist, B.M.S. and Punia, M.S., IJCM: XXIV-4, 175, 1999.

Mukherjee, G. and Ghose, T.K., J. Indian Medical Association. **92** (1), 37, 1994.

Saibaba, A., Sarma D.S., Balkrishan, N. and Raghuram, T.C., IJCM, XXIV-2:75, 1999.

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Management information system in context of health care delivery

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Abstract : Proper management information system can play an important role in collection, analysing and transmission of the information to the persons, places where it requires in minimum (optimal) resources particularly the precious "Time". The information thus we get is more authentic as well as cost effective which is ultimately helpful in timely proper planning and implementation of our health care delivery.

Key Words : M.I.S. Transmission, Transformation.

1. Introduction

"Appropriate decision making and programme planning in the health and health related fields is not possible without establishing an effective health information system. A nation wide organizational setup should be established to procure essential health information". The national health policy of India was adopted by the parliament in 1983.

The most successful chief executives are usually the best informed. Quality, timing and proper use of the facts determines the success or failure of the organisation. Accurate and timely information is required to manage the following process.

(a) To establish objectives of the organisation.
(b) To direct people and resources to attain these objectives.
(c) To evaluate the results.

(a) Estabilishing of objectives

1. Ultimate and intermediate objectives.
2. Clear definition of aims to be achieved in measurable terms.
3. Time in which objectives are to be achieved.

4. Target groups.

(b) To direct people and resources to attain these objectives

The second step in the managing process is the directing people and resources for attainment of these objectives. To achieve these objectives, organisation should be fully equipped with the information or prevailing conditions, the available resources and equipment. The right and timely information is a must for achieving these objectives.

(c) Measurement of results

In the development of an organisation, it is necessary to correct deficiencies and weaknesses and to improve procedures and operations. A major principle is that the good performance must be rewarded and the poor, must be corrected. This is usually achieved by comparing the actual performance with the standard set.

Management-information-system

(i) Management

Managing is a function of guiding and directing the activities of others to achieve desired goals. Good Manager will take it as service not control.

(ii) Information

Every data is not an information under MIS. It is only when the data is processed it is called information otherwise it is just a data.

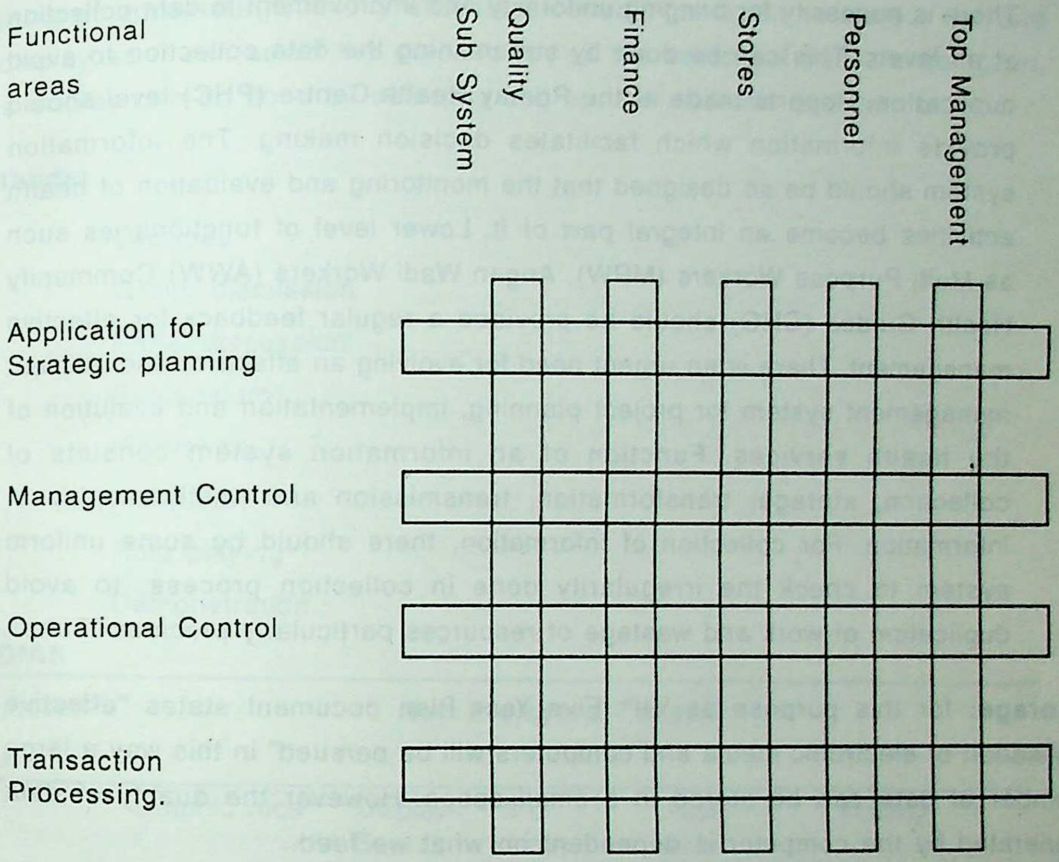
Data Collection Input -- Processing -- Output -- Dissemination

Output → Action

Dissemination →
- Members of Organisation.
- Public
- Government.
- Environment.

(iii) System

System is a group of parts or elements that are integrated for th common purpose of achieving some objectives. The various functional area are integrated through the common data base which is an integral part of the information system in an organisation.


Functional areas
Quality Sub System
Finance
Stores
Personnel
Top Management
Application for Strategic planning
Management Control
Operational Control
Transaction Processing.

Thus Management Information System (MIS) is an organised method of providing past, present and future information relating to internal operations and external intelligence. It supports the planning, control and operational functions of an organisation by furnishing pertinent information in proper time frame to assist the decision making process.

Our health services gather a lot of information both from formal and informal sources but most of these informations are not adequately utilised because -

1. Field workers often make duplicate efforts for collection of data which may be fragmented.

2. There is necessity for bringing uniformity and improvement in data collection at all levels. This can be done by streamlining the data collection to avoid duplication. Reports made at the Primay Health Centre (PHC) level should provide information which facilitates decision making. The information system should be so designed that the monitoring and evaluation of health activities become an integral part of it. Lower level of functionaries such as Multi Purpose Workers (MPW), Angan Wadi Workers (AWW) Community Health Guides (CHG) should be provided a regular feedback for effective management. There is an urgent need for evolving an effective, and efficient management system for project planning, implementation and evalution of the health services. Function of an information system consists of collection, storage, transformation, transmission and finally display of information. For collection of information, there should be some uniform system to check the irregularity done in collection process, to avoid duplication of work and wastage of resources particularly precious "Time".

Storage: for this purpose as VIIth Five Year Plan document states "effective utilisation of electronic media and computers will be persued" in this way a large number of data can be stored in a small space. However the quality of data generated by the computer is dependent on what we feed.

Transmission: is a process of transmission of stored information, ideas, thoughts, feelings, behaviour from one person or groups of person to other person or groups with a view to disseminate the selected information and thus to obtain desirable response to what is being transmitted. The key elements in transmission are one is transmitter. For a successful transmitter one must be well conversant with the objectives, his audience, its needs, its interest, mental capacity, socio-economic background etc., He should be well conversant with the content of the message, validity, usefulness and finally he should also know the operation of the channel's capacity to fulfil the needs and availability etc.

Transformation: Information should be transformed in such a way that it should be clear, understandable, specific, timely in local language, according to mental capacity and oriented for the needs of concerning masses.

Display of information: Finally what transformed information be stored, we have to display so it can serve the purpose for all the exercises that are going on. This display can be done by selecting appropriate methods and medias.

Methods:

Lectures
Group discussion
Panel discussion
Symposium
Workshop
Institution
Role playing
Demonstration

MEDIAS

Projected-Aids	**Non Projected - Aids**				
	Graphic Aids	Display-Boards	3-D Aids	Audio Aids	Activity
Slides Films, Overhead-Projecter, Cinema-slides.	Photographs, Pictures, Flashcards, Posters, Charts, Maps Graphs, Cartoons.	Black-boards, Flanel-boards, Magnetic-board	Models, Specinen, Television, Objects, Mocks	Radio, Recorder Folk-Songs.	Experiments, Demonstration, Folkdances, Dramatisation.

Finally we have to drawout a work plan. This list of the specific activities carried out by whom and when. Delegation of responsibility and orientation of person concern (he should know the importance of data in health programmes), should be done. In work plan it should be made clear how and who will supervise, example MPWs enter date in the field and health assistant and medical officer will verify these enteries giving their supervisory visits. MPWs should report to a PHC in a fix date alloted for entry of data and answer query if any. At this stage statistician presence have also an opportunity to look into the data. After the data entry is completed, the work plan is sent for each subcentre and handed over to workers.

The data includes - births, deaths, marriages, eligible couple, infants, cases of communicable and non-communicable diseases etc.etc. This data should be entered in PHC record upto date. Display of these data can be made in the PHC in form of graphs, diagrams, charts etc.

Tips for making MIS system as success:

a) Before introducing a report-its format, periodicity, responsibility for preparation and to whom to be submitted should be discussed in detail with the concerned persons so as to avoid any ambiguity and duplicity in the report.

b) As far as possible all information should be integrated in one report.

c) The regularity of report should be maintained.

d) Report should come in time so that basic purpose for which it is meant is not defeated.

e) Periodicity, format and contents of the report should be up-dated to suit the requirements of the organisation from time to time.

f) The report coming to the chief executive/departmental head should be properly verified by some one so as not to waste time in verifying the authenticity of the data.

g) Reports should be supported by graphs and charts, etc. where ever possible.

References

Bansal, A.K. and Chandorkar, R.K., Tribal Health Bulletin (I.C.K.R.), 4(1), 10, 1998.

Bansal A.K., Health Management Information System (Unpublished).

Dey, A.B., Health System in India, Employment News XXVI (3) 1, 2001.

Park, J.E. and Park, K., A Textbook of preventive and social medicine, 11th Edition, M/s. Banarsi Das Bhanot, Jabalpur, India, pp. 569, 1986.

Lal, Sunder, IJCM, XXIV(1)3, 1999.

Shah, Hemangini K. and Ganguli, S.K., IJCM XXV(3) 136, 2000.

Tuli K., Kapoor, S.K. and Nath, L.M., IJCM XV(3)151, 1990.

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Effect of annealing on some (Cd-Pb)S photoconducting films

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Abstract : Results of photoconductivity rise and decay, excitation and absorption spectra, XRD and SEM studics are presented for unannealed and annealed conditions. Due to annealing dark current is found to be zero and thus the ratio of photocurrent to dark current goes to infinitely high value. Values of trap depth E., lifetime t, and mobility u are also evaluated from photoconductivity decay. Band gaps are determined from the two spectra. Diffraction lines in XRD studies are associated to CdS and PbS. SEM studies show growth of layered structure.

Key Words : Photoconduction, (Cd-Pb)S films, chemical deposition.

1. Introduction

Recently chemical deposition method of films of CdS type of materials has drawn attention of a number of workers (Nair et al., 1989; Karanjai et al., 1987; Bhushan et al., 1990 1 & 2, 1992). Quite high photoconducting gain has been reported by these workers. In our earlier paper (Bhushan et al-2001), photoconductivity of (Cd-Pb)S films was reported. The present paper in continuation, reports the effect of annealing on the photo conducting (Cd-Pb)S films. Results of photoconductivity rise and decay, excitation and absorption spectra, X-ray diffraction and SEM studies are presented for such systems.

2. Experimental

The film preparation and experimental arrangements are described in our earlier publication (Bhushan et al-2001) Intensity variation was made by using neutral density filters. Annealing was done at 400°C for 2 min. Absorption spectra were recorded by using a Varian (UV-VIS) DMS-100 spectrophotometer. XRD studies were made at RSIC, Nagpur, using a Philips diffractrometer. Further SEM studies were performed at BSIP, Lucknow using Leo (430) SEM.

3. Results and discussions

3.1 Rise and decay curves

Photoconductivity rise and decay of a number of films were studied. Table-1 summarizes the dark current (Idc) and the ratio Ipc/Idc for a number of films. Due to annealing the dark current is found to be zero and thus although the photocurrent also decreases in this case but the ratio becomes infinity. The general nature of rise and decay is similar. This behavior for a particular sample $(Cd_{0.95}\text{-}Pb_{0.05})$ S: NaF, La $(NO_3)_3$ is shown in fig. -1. this is characterized by a fast rise in the beginning followed by saturation. The latter sets in when the recombination becomes dominant. Earlier workers considered the slowly increasing component of the photocurrent in (Cd-Zn)S films due to enhanced mobility (Shrivastava et al., 1996).

Table-1 Values of Idc, Ipc and Ipc/Idc of CdS (Cd-Pd)S and doped films in unannealed and annealed coditions (Temp. of deposition=60°C, time of deposition =1 hr., voltage = 15volts, annealing temp. =400°C, annealing time = 2 min.)

Systems	Unannealed			Annealed		
	Idc,nA	Ipc,μA	Ipc/Idc	Idc	Ipc,μA	Ipc/Idc
1. CdS	0.1	32	3.2×10^5	2 nA	35	1.72×10^5
2. $(Cd_{0.95}\text{-}Pb_{0.05})S$	0.05	30	6×10^5	Tends to 0	26	$\cong\infty$
3. $(Cd_{0.90}\text{-}Pb_{0.20})S$	0.1	13	1.3×10^5	Tends to 0	11	$\cong\infty$
4. $(Cd_{0.80}\text{-}Pb_{0.20})S$	0.1	12	1.2×10^5	Tends to 0	10.5	$\cong\infty$
5. $(Cd_{0.98}\text{-}Pb_{0.02})S$	0.1	12.5	1.25×10^5	Tends to 0	10	$\cong\infty$
6. $(Cd_{0.95}\text{-}Pb_{0.05})S$:NaF(12ml.)	0.1	168	1.68×10^6	Tends to 0	157	$\cong\infty$
7. $(Cd_{0.05}Pb_{0.05})S$:NaF, $La(NO_3)_3$ (10ml.)	0.5	85	1.7×10^6	Tends to 0	78	$\cong\infty$

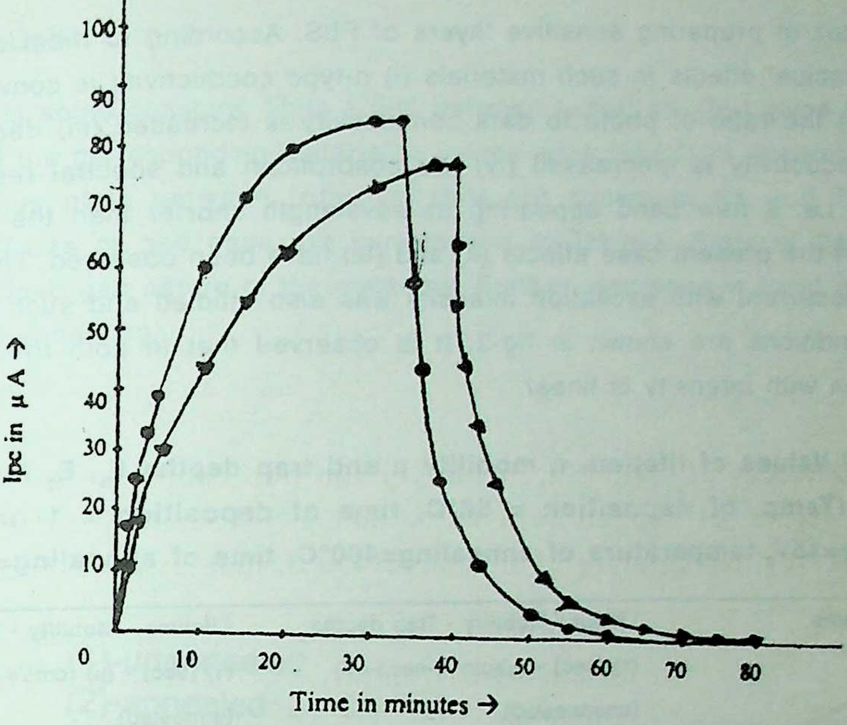

Fig.-1 Rise and decay curves for $(Cd_{0.95}\text{-}Pb_{0.05})S:NaF,La(NO_3)_3$ films, 0-unannealed, A-annealed.

The analysis of the photoconductivity decay curves for trap depth values (E_1 and E_2) and evaluation of lifetime (τ) and mobility(μ) are described in our earlier publication (Bhushan et al., 2001). The values of E τ, μ and trap depths obtained in this way are summarized (for unanncaled and annealed cases) in table-2. It is observed that both τ and μ increase due to presence of impurity, which may be the cause of higher current. Due to annealing of CdS sample, the values of τ and μ decrease a little. Innc case of Pb mixed samples, the photoconductivity gain tends towards infinity, so corresponding μ also tends towards infinity, although there is small decrease in the value of τ. Thus, factors responsible for sensitizatio may be the increased lifetime and mobility. However, the cause of zero dark current in Pb mixed samples is not exactly known. Probably it may be due to oxygen acting as an acceptor which has occurred duringn annealing in air. Shikalgar et al. (1977) found that for longer annealed films of CdS, oxygen played an important role in decreasing the photoconductivity. According to earlier workers (Bube 1967) use of oxygen plays an integral role in the art of preparing sensitive layers of PbS. According to them oxygen has four principal effects in such materials (i) n-type conductivity is converted to p-type (ii) the ratio of photo to dark conductivity is increased (iii) decay time of photocoductivity is inncreased (iv) the absorptionn and spectral response are altered i.e. a new band appearing at wavelength shorter than the absorption edge. In the present case effects (ii) and (iii) have been observed. The variation of photocurrent with excitation intensity was also studied and such results for two conditions are shown in fig-2. It is observed that in both the cases the variation with intensity is linear.

Table-2 Values of lifetime τ, mobility μ and trap depths E_1, E_2 for different films. (Temp. of deposition = 60°C, time of deposition = 1 hr., applied voltage=15V, temperature of annealing=400°C, time of annealing=2min.)

Systems	Lifetime-Mobiliry - Trap depths (τ) (sec) - (μ)(cm²/V-sec.)-eV) (unannealed)			Lifetime - Mobility - Trap depths (τ) (sec) - (μ) (cm²/V-sec.)-(eV) (annealed)		
1. CdS	19.89	42.90	E_1=0.771, E_2=0.712	15.2	30	E_1=0.793, E_2=0.763
2. $(Cd_{0.98}\text{-}Pb_{0.02})S$	34.3	53.3	E_1=0.502, E_2=0.538	31.2	~ ∞	E_1=0.512, E_2=0.522
3. $(Cd_{0.95}\text{-}Pb_{0.05})S$	31.11	51.44	E_1=0.505, E_2=0.567	29.3	~ ∞	E_1=0.699 E_2=0.632
4. $(Cd_{0.90}\text{-}Pb_{0.10})S$	24.4	14.2	E_1=0.792, E_2=0.773	23.02	~ ∞	E_1=0.826, E_2=0.819
5. $(Cd_{0.80}\text{-}Pb_{0.20})S$	17.3	18.14	E_1=0.810, E_2=0.802	15.8	~ ∞	E_1=0.844, E_2=0.823
6. $(Cd_{0.95}\text{-}Pb_{0.05})S$:NaF	48.01	93.33	E_1=0..587, E_2=0.612	39.3	~ ∞	E_1=0.721, E_2=0.709
7. $(Cd_{0.95}\text{-}Pb_{0.05})S$: NaF,La	47.77	94.83	E_1=0.734, E_2=0.756	38.52	~ ∞	E_1=0.891, E_2=0.867

3.5 Excitationn and absorption spectra

Results of excitation spectra of (Cd-Pb)S: NaF, $La(NO_3)_3$ samples are shown in fig.-3 for unannealed and annealed conditions. Similarly, the results of absorption spectra are shown in fig.-4. The optical absorption coefficient (α) and band gap Eg for direct band gap material are represented by the equation (Dawar et al., 1990).

$$\alpha = C(h\upsilon - Eg)^{1/2}/h\upsilon$$

Where C is some constant. Thus a plot between $(\alpha h\upsilon)^2$ vs. $(h\upsilon)$ gives the band gap Eg of the corresponding material. α values were take from absorption spectra and thus plots between $(\alpha h\upsilon)^2$vs. $(h\upsilon)$ are shown in fig. - 5 The correspoding values of bad gaps are summarized in Table-3. Plots of fig.-5 indicate direct band gap nature of the materials. Further, decrease in band gap is found due to annealing.

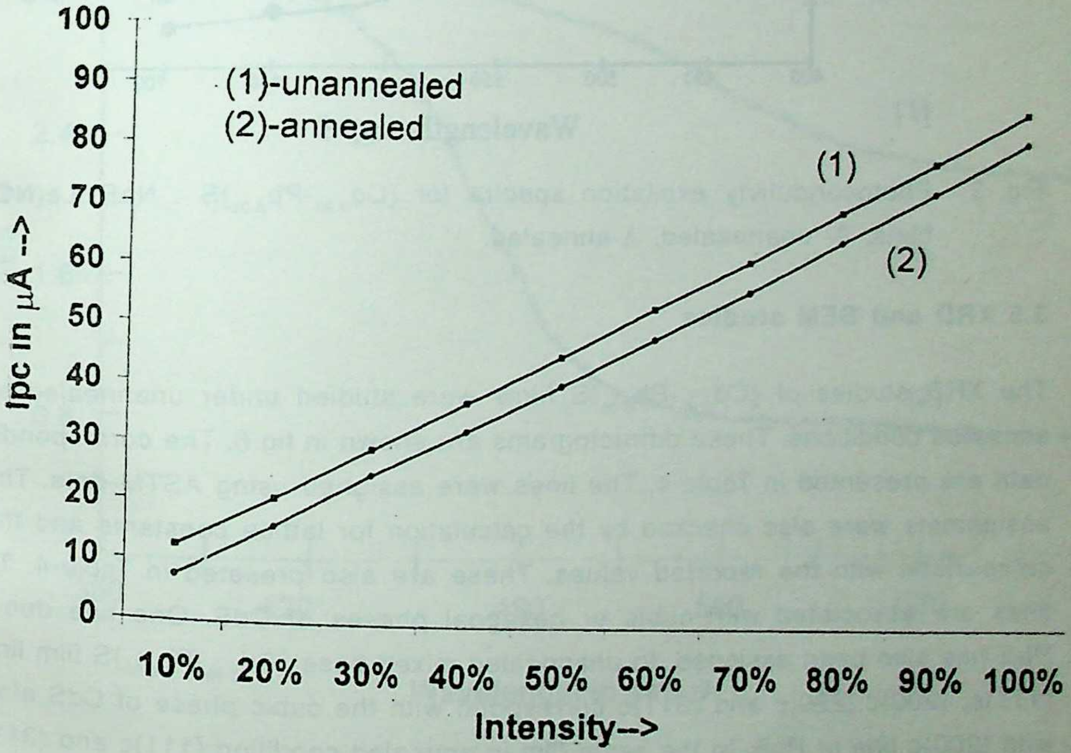

Fig.-2 Variation of photocurrent with excitation intensity for $(Cd_{0.95}\text{-}Pb_{0.05})S$: NaF, $La(NO_3)_3$ films, (1) - unannealed, (2) -annealed.

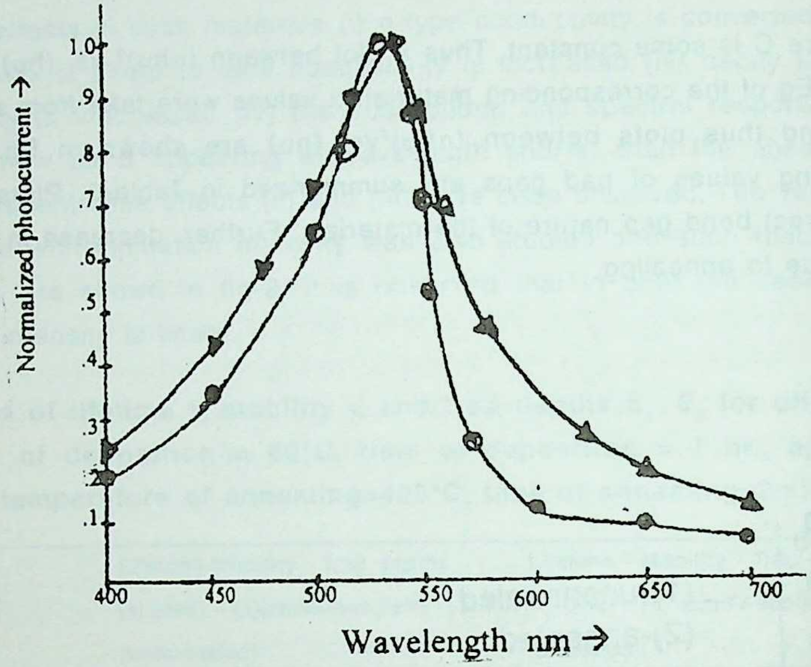

Fig.-3 Photocondutivty excitation spectra for $(Cd_{0.95}-Pb_{0.05})S$: NaF, $La(NO_3)$ films, 0- unannealed, Δ-annealed.

3.5 XRD and SEM studies

The XRD studies of $(Cd_{0.95}-Pb_{0.05})S$ films were studied under unannealed and annealed conditions. These diffractograms are shown in fig.6. The corresponding data are presented in Table-4. The lines were assigned using ASTM data. Thei assignmets were also checked by the calculation for lattice constants and thei comparison with the reported values. These are also preseted in Table-4. The lines are associated with cubic or hexagoal phases of CdS. One line due to PbS has also been assigned. In unannealed mixed base $(Cd_{0.95}-Pb_{0.05})S$ film lines (111)c, (200)c,(220)c and (311)c correspond with the cubic phase of CdS along with (200)c line of PbS. In the same film in annealed condition (111)c and (311) lines of CdS along with (220)c line of PbS were found. After annealing line (200)c and (220)c of CdS disappear. SEM micrographs of different films wer also investigated. For a representative sample of $(Cd_{0.95}-Pb_{0.05})S$ film unde unannealed and annealed conditions such micrographs at a magnification of 20 are shown in fig.-7. Both show cabbage type structure. Such structures indicate layered growth of the material. These layers under continued growth condition formed cabbage. In unannealed condition, more voids are seen.

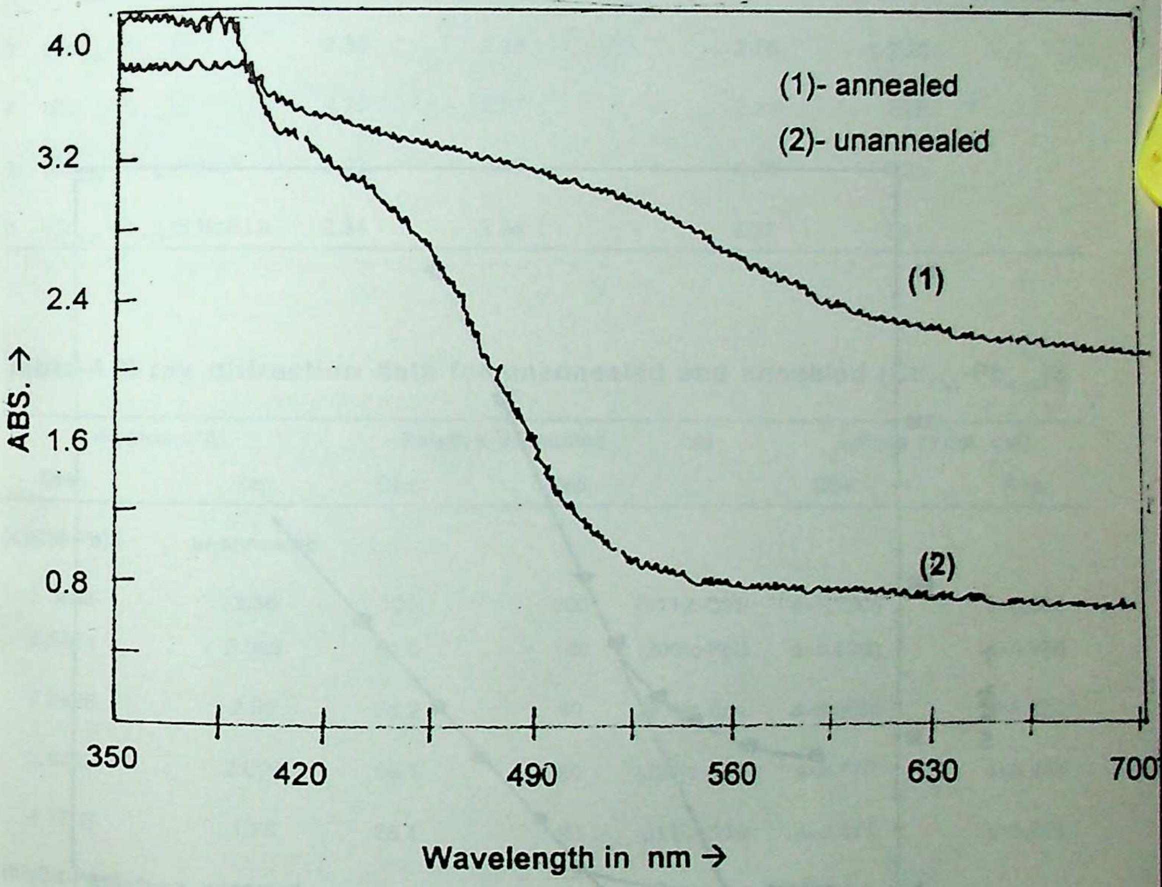

Fig.-4 Absorption spectra for $(Cd_{0.95}-Pb_{0.05})S$: NaF, $La(NO_3)_3$ films, 1-annealed, 2-unannealed.

Conclusions

Substitutions of Pb in place of Cd in CdS results in zero dark current under annealing condition. Thus, the ratio Ipc/Idc increases to infinitely high value. The lifetime and mobility of carriers increase due to presence of impuritiy. Band gaps determined from photoconductivity excitation spectra and absorption spectra decrease due to annealinng. The XRD patterns show presennce of both CdS and PbS. In CdS hexagonal and cubic phases, both are assigned. SEM micrographs show growth of layered structure with more voids under unannealed coditions.

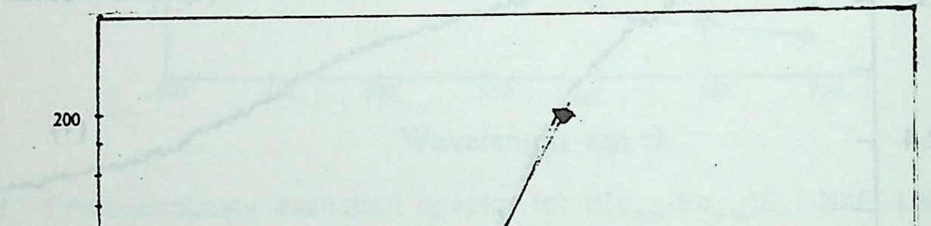

Fig.-5 Plot of $(ah\upsilon)^2$vs. $(h\upsilon)$ for $(Cd_{0.95}\text{-}Pb_{0.05})S$: NaF, $La(NO_3)_3$ films, O-unannealed, Δ-annealed.

Table-3 Band gap values determined from excitation and absorption spectra for different films in unannealed and annealed conditions: (Temp. of deposition = 60°C. time of deposition=1 hr., applied voltage=150V, temperature of annealing=400°C, time of annealing = 2min.).

Systems	(unannealed)Eg-from excitation - spectra	absorption spectra	(annealed) Eg-from excitation - spectra	absorption spectra
1. CdS	2.42 -	2.40	2.41 -	2.17
2. $(Cd_{0.98}$-$Pb_{0.02})S$	2.38 -	2.29	2.29 -	2.25
3. $(Cd_{0.95}$-$Pb_{0.05})S$	2.30 -	2.28	2.26 -	2.26
4. $(Cd_{0.90}$-$Pb_{0.10})S$	2.25 -	2.27	2.23 -	2.20
5. $(Cd_{0.95}$-$Pb_{0.05})S$:NaF	2.23 -	2.33	2.22 -	2.25
6. $(Cd_{0.95}$-$Pb_{0.05})S$:NaF,La	2.34 -	2.36	2.31 -	2.11

Table-4 X-ray diffraction data for unannealed and annealed $(Cd_{0.95}$-$Pb_{0.05})S$

d-values(°A)		Relative intensities		hkl	Lattice const. (°A)	
Obs.	Rep.	Obs.	Rep.		Obs.	Rep.
(a)(Cd-Pb)S	**unannealed**					
3.3086	3.36	100	100	(111)c-CdS	a=5.7306	a=5.833
3.0451	2.969	81.0	100	(200)c-PbS	a=6.0902	a=5.936
2.8426	2.90	56.2	40	(200)c-Cds	a=5.6856	a=5.833
2.0432	2.058	60.1	80	(220)c-CdS	a=5.778	a=5.833
1.7703	1.76	68.1	90	(311)c-CdS	a=5.871	a=5.833
(b)(Cd-Pb)S	**annealed**					
3.3117	3.36	100	100	(111)c-CdS	a=5.736	a=5.833
3.0426	2.969	60.1	100	(200)c-PbS	a=6.0856	a=5.936
1.733	1.76	18.4	90	(311)c-CdS	a=5.7487	a=5.833

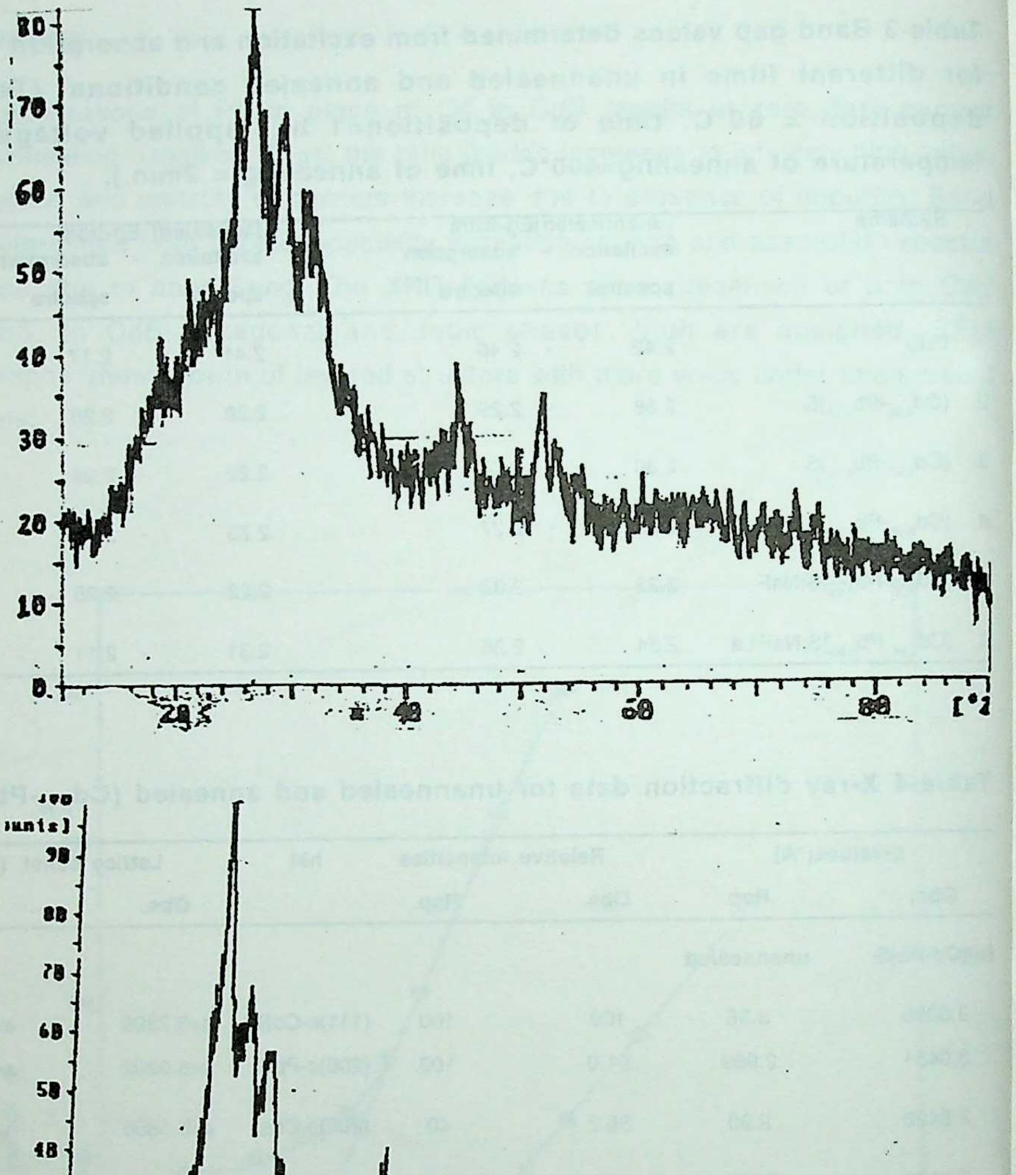

Fig. 6 X-ray diffractograms for $(Cd_{0.95}-Pb_{0.05})S$ unannealed and annealed films.

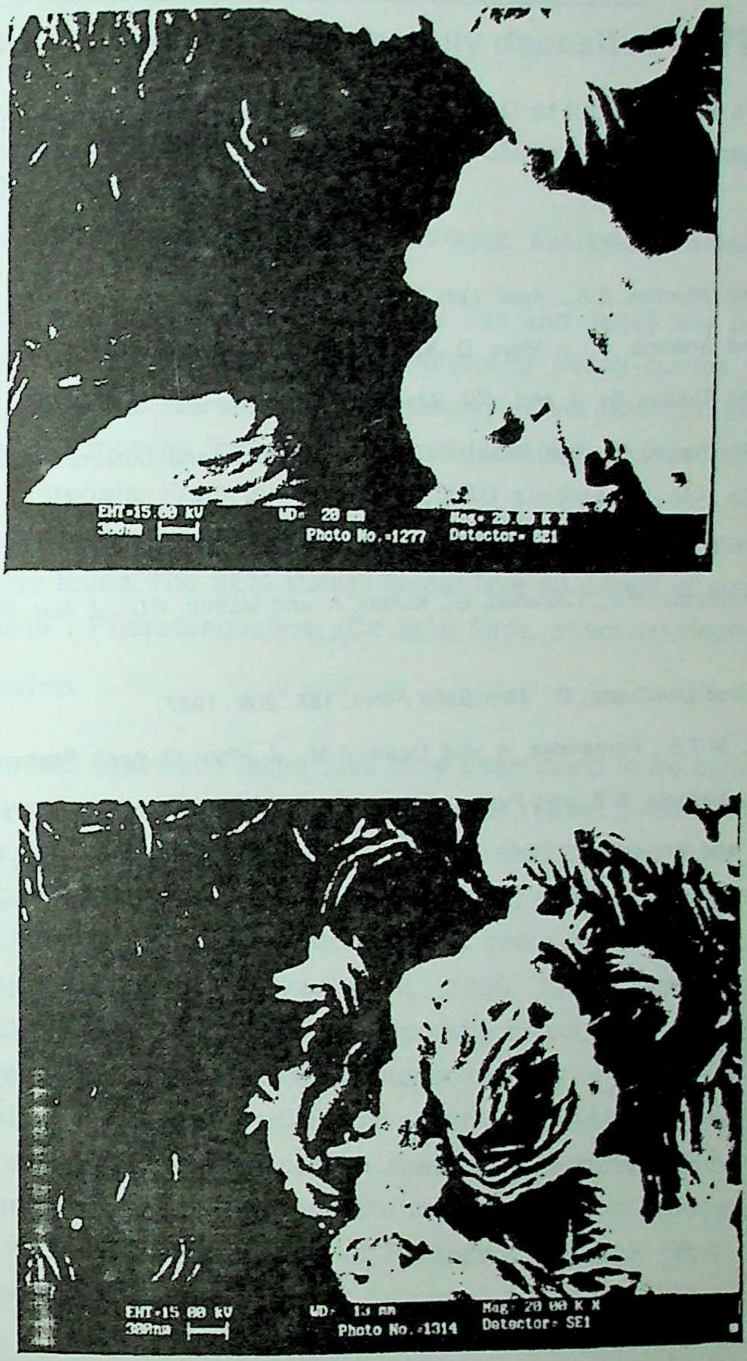
EHT=15.00 kV
300nm
WD= 20 mm
Photo No.=1277
Mag= 20.00 K X
Detector= SE1
EHT=15.00 kV
300nm
WD= 13 mm
Photo No.=1314
Mag= 20.00 K X
Detector= SE1

Fig.- 7 SEM micrographs for $(Cd_{0.95}-Pb_{0.05})S$ unannealed and annealed films.

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References

Bhushan, S. and Sharma, S.K., *Appl. Lett.*, **57**, 884, 1990.

Bhushan, S. and Sharma, S., J. Phys. D. *Appl. Phys.*, **23**, 909, 1990.

Bhushan, S. and Thakur, D., *J. Mat. Sci. (Materials in Electronics)*, **3**, 35, 1992.

Bhushan, S., Mukherjee, M. and Bose, P., Radiation Effects and Defects in Solids, **135**, 367, 2001.

Bube, R.H., *Photoconductivity of Solids, John Wiley*, pp. 175, 1967.

Dawar, A.L., Shishodia, P.K., Chauhan, G., Kumar, A. and Mathur, P.C., *J. Mat. Sc. Lett.*, **9**, 547, 1990.

Karanjai, M.K. and DasGupta, D., *Thin Solid Films*, **155**, 309, 1987.

Nair, P.K., Nair, M.T.S., Fernandez, A. and Ocampo M., *J. Phys. D. Appl. Phys.*, **22**, 829, 1989.

Shikalgar, A.G., Bargale, B.B. and Pawar, S.H., *Ind. J. of Pure ad Appl. Phys.*, **15**, 747, 1997.

Shrivastava, S. and Bhushan, S., *Ind. J. of Pure and Appl. Phys.* **34**, 106, 1996.

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Photoconductivity of some chemically deposited (Cd-Zn)S films

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Abstract : Results of photoconductivity rise and decay are presented for different (Cd-Zn)S films. From the analysis of decay curves trap depths, instantaneous life time and mobility are evaluated. Both the instantaneous life time and mobility improve which produce high photocurrent observed in such materiats. From the results of XRD studies, crystal structure and lattice constants are evaluated. Existence of both cubic and hexagonal phases are found. The SEM studies favour layered growth of such materials.

Key Words : Photoconduction, (Cd-Zn)S films, chemical deposition.

1. Introduction

The chemical deposition techniques have been found to be quite interesting and have drawn interest of number of workers in recent years (Mondel et al., 1983; Nair et al., 1988; Bhushan et al., 1990; 1995; 2001). Such techniques provide cheaper and simpler methods. Nair et al. (1983) reported at least a thousand fold improvement in the optoelectronic characteristics of solar assisted chemically deposited films. Bhushan et al. (1990, 1992, 1995 & 2001) found many fold improvements in the photoconductivity of such compounds. Bhushan and Shrivastava (1995,1996) reported photoconductivity in lanthanum-neodymium doped (Cd-Zn)S films. In our earlier publication (Bhushan and Sahu, 2000) we reported rise and decay and absorption spectra of samarium (Sm) doped (Cd-Zn)S films. The present paper reports the results of rise and decay, absorption spectra, and XRD and SEM studies of Pr doped (Cd-Zn)S films prepared by chemical deposition technique.

2. Experimental

The details of film preparation are already reported in the earlier publication (Bhushan and Sahu, 2000). The photocurrents were measured by using a nanoammeter (Scientific equipment Roorkee NM 122) and the absorption spectra were studied by a Varian (UV-VIS) DMS 100 spectrophotometer. XRD studied were done at RSIC Nagpur using a Philips diffractometer with Cu Kα radiation. SEM studies were performed at BSIP Lucknow using Leo (350) SEM.

3. Results and discussion

3.1. Rise and decay studies

The results of rise and decay cruves of different CdS and $(Cd_{0.7}\text{-}Zn_{0.3})S$ films are shown in fig. 1. Selection of $(Cd_{0.7}\text{-}Zn_{0.3})S$ was made on the basis of satisfactorily high value of the ratio I_{pc}/I_{DC} along with proper band gap for visible excitation. Films were also prepared at different dipping fimes and one hour deposition time was selected on the basis of highest I_{pc}/I_{pc} ratio. The values of I_{pc}/I_{pc} and I_{pc}/I_{DC} ratio for different films are presented in table-1. High photosensitivity in such compounds are normally associated with the presence of compensated acceptors by earlier workers (Bube, 1967). This compensation effect can be obtained with donor as well as acceptor impurities. The compensated acceptors are negatively charged and thus they have a much longer cross section for capture of the free holes than they have subsequently for the capture of electrons. Trivalent Pr may act as donor. Although intitial increase is due to photo carrier generation and the slowly increasing component of the photocurrent could be due to enhanced mobility. By resolving hyperbolic decay curves into possible number of the exponentials the trap depths were calculated, which are presented in table 2. Method of finding instantaneous life time (τ) and mobility (μ) is described in earlier paper (Bhushan et al., 2001). The rules of τ & μ thus obtained in this way are summarized in table 2. It is observed that both these values increase due to the presence of impurities which may be a reason for high photosensitivity.

3.2 Absorption spectral studies

The absorption spectra for different films are shown in fig-2. The optical absorption coefficient (α) and band gap E_g for direct band gap material is represented by the equation (Dawar et al., 1990).

Table - 1 Values of Idc.Ipc & the ratio Ipc/Idc for different films. Preparation temperature = 60°C. Time of deposition - 1hr

S.No.	Films	I_{dc} nA	I_{pc} μA	I_{pc}/I_{dc}
1.	CdS	0.4	5.20	$.12\times10^5$
2.	$(Cd_{0.7}-Zn_{0.3})S$	02	30.1	1.5×10^5
3.	$(Cd_{0.7}-Zn_{0.3})S$:NaF(5ml.)	0.6	175	2.9×10^5
4.	$(Cd_{0.7}-Zn_{0.3})S$:NaF(5ml.) $Sm(NO_3)_3$ 3ml.	0.1	111	1.110×10^6
5.	$(Cd_{0.7}-Zn_{0.3})S$:NaF(5ml.) $Pr(NO_3)_3$ 3Ml.	0.1	88.1	8.81×10^5

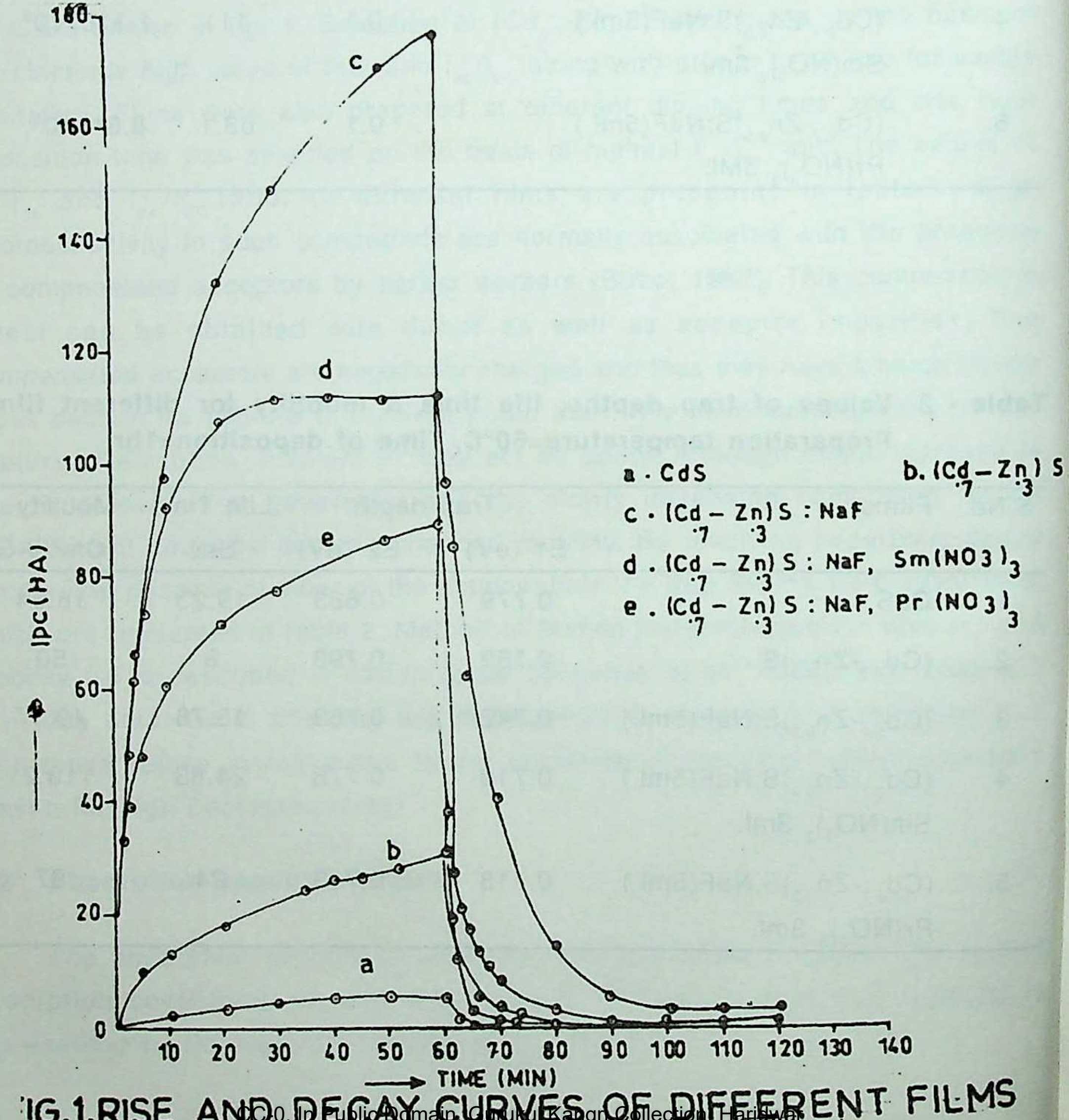
Table - 2 Values of trap depths, life time & mobility for different films Preparation temperature=60°C, Time of deposition=1hr

S.No.	Films	Trap depth		Life Time	Mobility μ
		E1 (eV)	E2 (eV)	Sec	Cm²/V-S
1.	CdS	0.779	0.683	19.23	16.64
2.	$(Cd_{0.7}-Zn_{0.3})S$	0.752	0.793	8	50
3.	$(Cd_{0.7}-Zn_{0.3})S$:NaF(5ml.)	0.742	0.753	15.78	49.17
4.	$(Cd_{0.7}-Zn_{0.3})S$:NaF(5ml.) $Sm(NO_3)_3$ 3ml.	0.719	0.778	24.83	119.21
5.	$(Cd_{0.7}-Zn_{0.3})S$.NaF(5ml.) $Pr(NO_3)_3$ 3ml.	0.718	0.763	24	97

$$\alpha=(h\upsilon-E_g)^{1/2}/h\upsilon$$

Where c is some constant.

Thus, a plot between ($\alpha h\upsilon$) vs ($h\upsilon$) gives the band gap E_g of the corresponding material. Such a plot for one representative sample of (Cd-Zn)S NaF. Pr is shown in fig.-3. The values of band gap for different materials are summarised in table-3.



'IG.1.RISE AND DECAY CURVES OF DIFFERENT FILMS

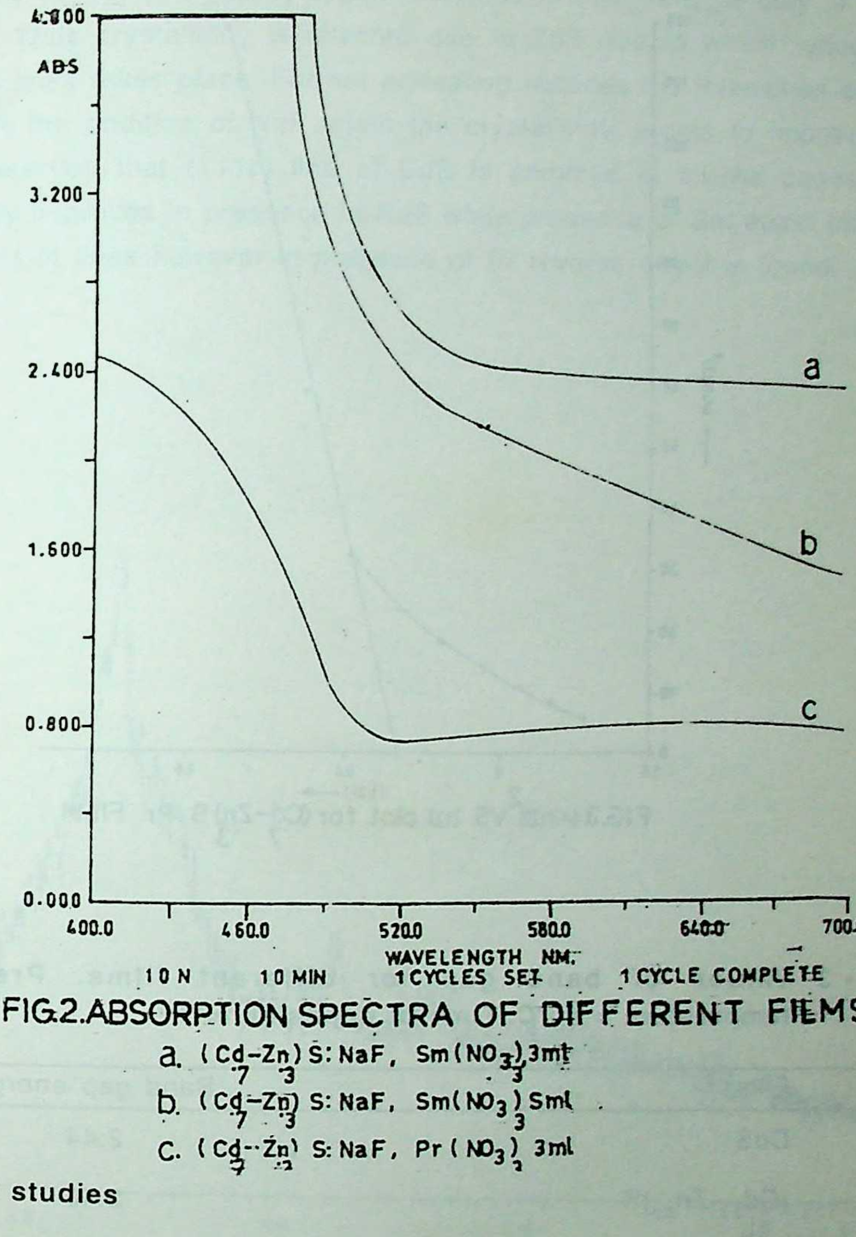


FIG.2. ABSORPTION SPECTRA OF DIFFERENT FILMS

a. $(Cd_{.7}-Zn_{.3})S$: NaF, $Sm(NO_3)_3$ 3ml

b. $(Cd_{.7}-Zn_{.3})S$: NaF, $Sm(NO_3)_3$ 5ml

c. $(Cd_{.7}-Zn_{.3})S$: NaF, $Pr(NO_3)_3$ 3ml

3.3 XRD studies

XRD diffractograms of different films are shown in fig.-4 and their corresponding data are presented in table-4. The assignment of the diffraction lines have been made from ASTM data. Confirmation has also been made by making calculation of lattice constants (a for cubic and c/a for hexagonal). It is observed that in CdS diffraction lines due to (100h), (111c), (200c) and (112h) appear. Due to mixing of ZnS the number of lines reduces for example in ($Cd_{0.7}$-

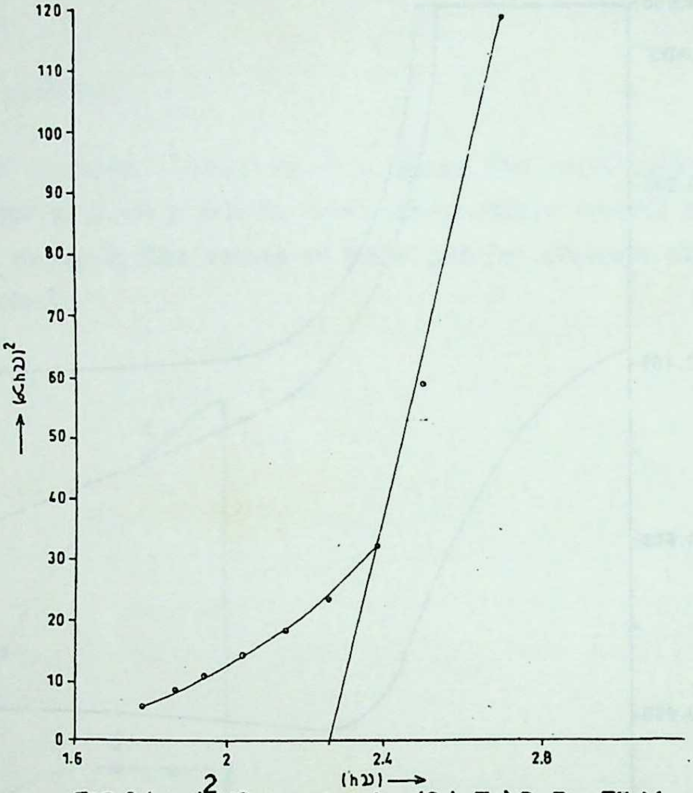


FIG.3. $(\alpha h\nu)^2$ VS $h\nu$ plot for $(Cd_{.7}-Zn_{.3})S$ Pr FILM

Table - 3 Values of band gap for different films. Preparation temperature = 60°C. Time of deposition=1hr

S.No.	Films	Band gap energy
1.	CdS	2.44
2.	$(Cd_{0.7}-Zn_{0.3})S$	2.46
3.	$(Cd_{0.7}-Zn_{0.3})S$:NaF(5ml.)	2.31
4.	$(Cd_{0.7}-Zn_{0.3})S$:NaF(5ml.) $Sm(NO_3)_3$ 3ml.	2.29
5.	$(Cd_{0.7}-Zn_{0.3})S$:NF(5ml.) $Pr(NO_3)_3$ (3ml.)	2.26

$Zn_{0.3}$)S only (111c) and (220c) appear whereas in ($Cd_{0.7}$-$Zn_{0.3}$)S only (111c), is observed. Thus crystallinity is affected due to ZnS due to which reduction in diffraction lines takes place. Further annealing reduces the intensities of these lines. With the addition of NaF again the crystallinity seems to improve. It is mainly observed that (111c) line of CdS is common in all the cases. Thus crystallinity improves in presence of NaF while presence of Sm again improves the number of lines however in presence of Pr reverse effect is found.

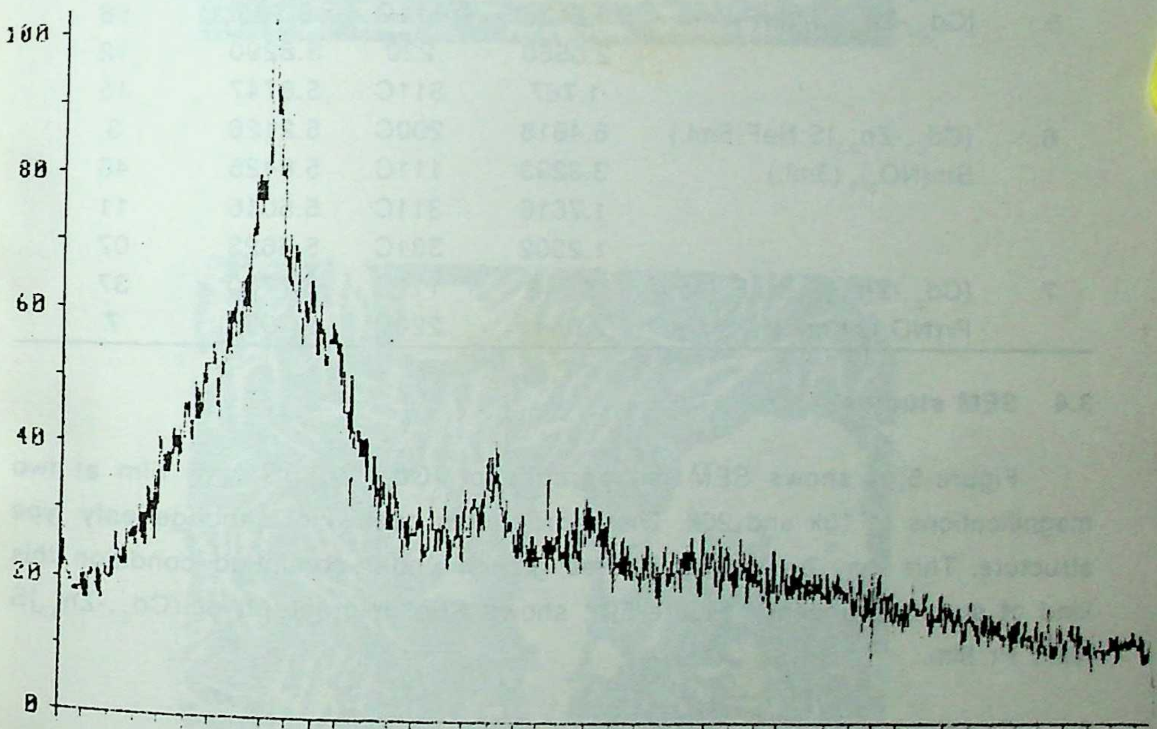


Fig. 4. X-Ray Spectrograph of (Cd-Zn)s Naf, Pr (No), Film

Table - 4 Values of d, hkl, a and Intensity for different films. Preparation temperature = 60°C, Time of deposition = 1hr

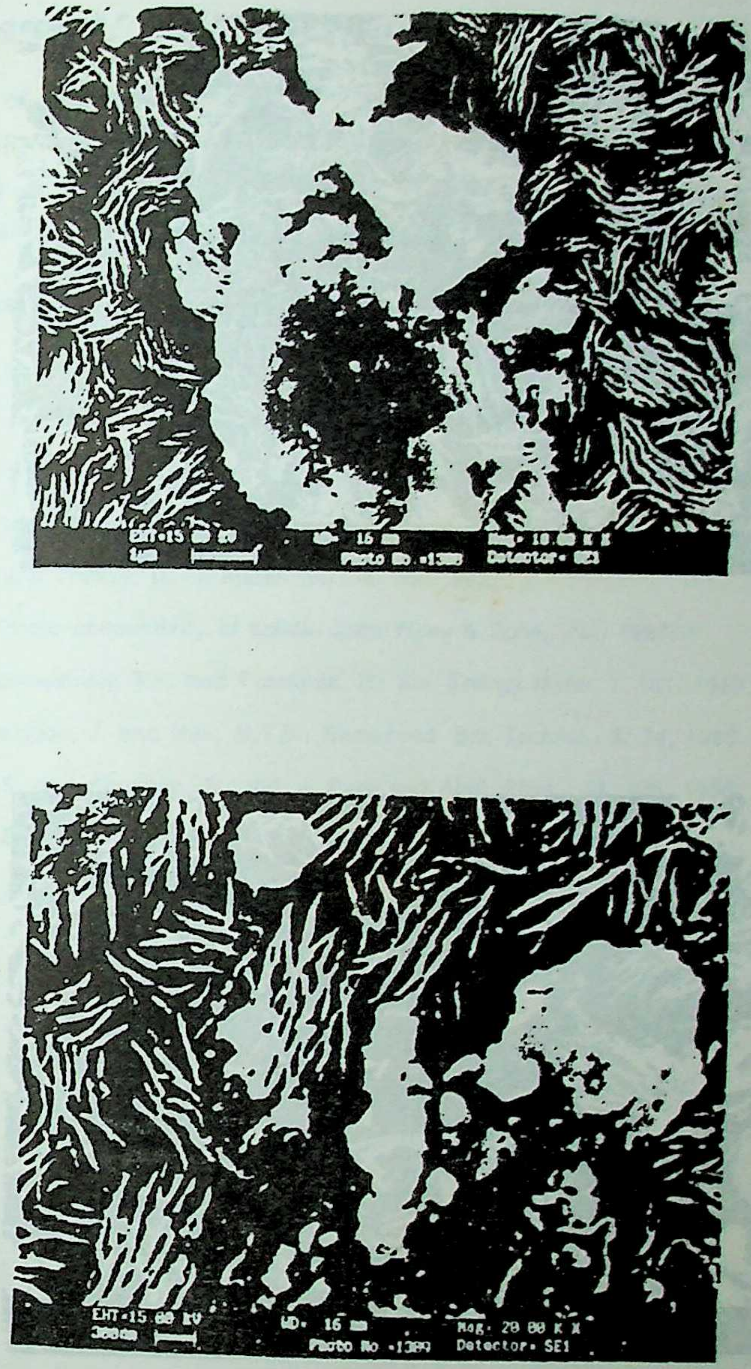
S.No.	Films	d (A°)	hkl	a(A°)	Intensity
1.	CdS	3.5167	100th	c/a 1.79	10
		3.3422	111C	a=4,4825	34
		2.8246	200C	a=5.659	10
		1.7673	112h	c\a=1.77	7
2.	$(Cd_{0.7}\text{-}Zn_{0.3})S$ Annealed	3.3274	111C	a=5.632	28
		2.0386	220C	5.7439	8
3.	$(Cd_{0.7}\text{-}Zn_{0.3})S$ Unannealed	3.3372	111C	5.7798	42
		2.0386	220C	5.7945	12
4.	$(Cd_{0.6}\text{-}Zn_{0.4})S$	3.3336	111C	5.7739	55
5.	$(Cd_{0.7}\text{-}Zn_{0.3})S$ NaF(5ml)	3.3135	111C	5.739	58
		2.0560	220	5.8290	12
		1.767	311C	5.8747	15
6.	$(Cd_{0.7}\text{-}Zn_{0.3})S$:NaF(5ml.) $Sm(NO_3)_3$ (3ml.)	6.4818	200C	5.2126	3
		3.3293	111C	5.8425	46
		1.7616	311C	5.5016	11
		1.2302	331C	5.3623	07
7.	$(Cd_{0.7}\text{-}Zn_{0.3})S$. NaF (5ml.) $Pr(NO_3)_3$ (3ml.)	3.342	111C	5.7750	37
		2.0441	220C	5.7960	7

3.4 SEM studies

Figure-5(a) shows SEM micrographs of $(Cd_{0.7}\text{-}Zn_{0.3})S$ NaF film at two magnifications of 10k and 20k. The micrographs consist of cabbage/leafy type structure. This may be due to layered growth under continued condition this kind of structure appears. Figure-5(b) shows SEM micrograph of $(Cd_{0.7}\text{-}Zn_{0.3})S$ NaF: Pr film.

4. Conclusion

Ratio $I_{pc}/I_{DC}=1.11\text{x}10^6$ is obtained for Sm doped $(Cd_{0.7}\text{-}Zn_{0.3})S$: NaF samples. The instantaneous life time and mobility, improve which may be a reason for high ratio XRD studies show both combination of hexagonal and cubic phases. The SEM studies favour layered growth of such materials.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1μm
WD= 16 mm
Photo No.=1388
Mag= 10.00 K X
Detector= SE1
EHT=15.00 kV
300nm
WD= 16 mm
Photo No.=1389
Mag= 20.00 K X
Detector= SE1

Fig. 5a. Scanning electron micrograph of (Cd-Zn) S: Naf, Pr Film
(i) Magnification 10K (ii) Magnification 20 K

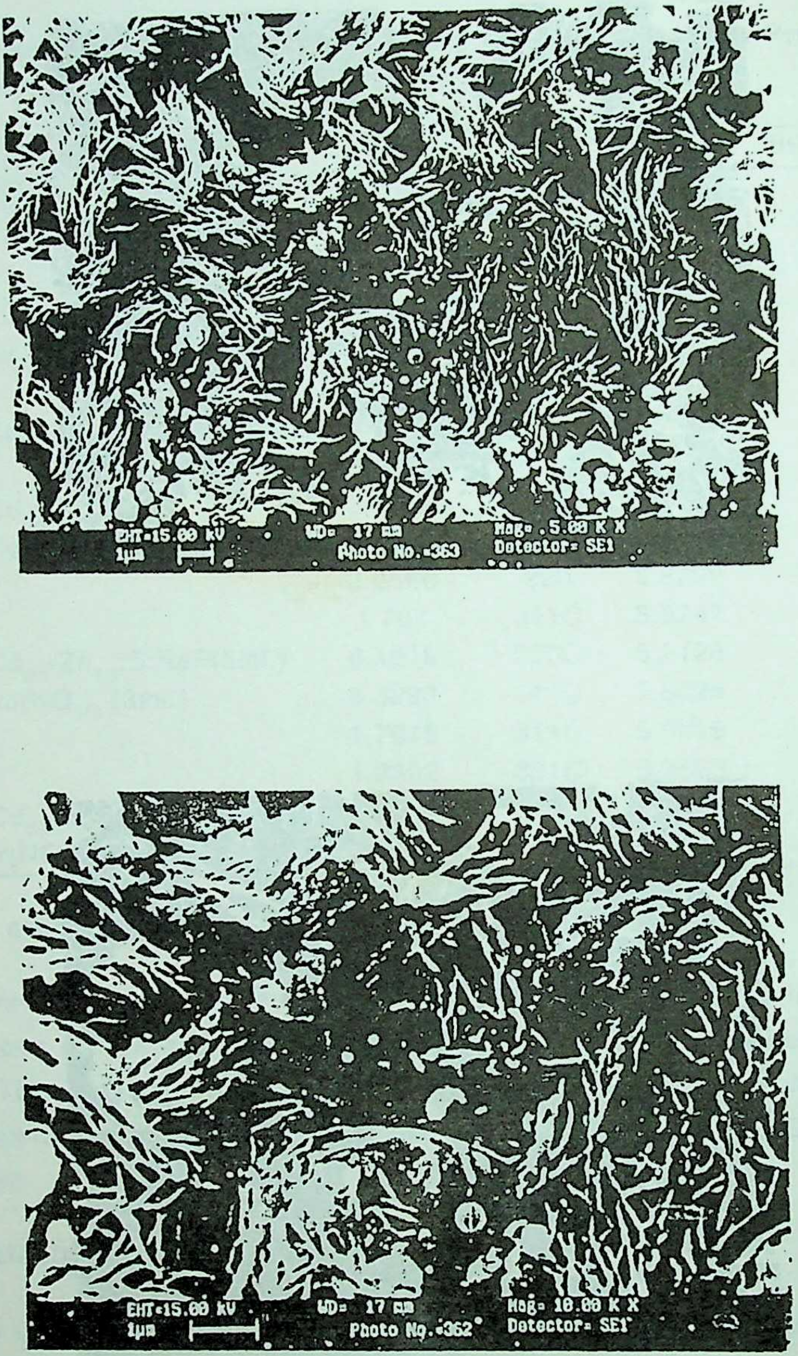
EHT=15.00 kV
1μm
WD= 17 mm
Photo No.=363
Mag= 5.00 K X
Detector= SE1
EHT=15.00 kV
1μm
WD= 17 mm
Photo No.=362
Mag= 10.00 K X
Detector= SE1

Fig. 5b. Scanning electron micrograph of (Cd-Zn) S: Naf, Pr Film (i) Magnification 5K (ii) Magnification 10 K

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References

Bhushan, S. Mukharjee M. and Bose, P., Radiation effect and defects in solids, **153**, 367, 2001.

Bhushan, S. and Sahu, R.B., J.R.S. Univ., **23** (B) 6U (ISSN 0970-5910), 2000.

Bhushan, S. and Sharma, S.K., Appl. Phys. Lett. (U.S.A.), **57** (9), 884, 1990.

Bhushan, S. and Shrivastava, S., Indian J. Pure and Appl. Phys., **33**, 371, 1995.

Bhushan, S. and Thakur, D., J. Mater. Sci., **3**, 35, 1992.

Bube, R.H., Photo conductivity of solids, John Wiley & Sons, Inc., 1967.

Mondal, A., Choudhary, T.K. and Pramanik, P., Sol. Energy Mater, **I**, 131, 1983.

Nair, P.K., Campos, J. and Nair, M.T.S., Semi-cond. Sci. Technol., **3**, 34, 1988.

Shrivastava, S. and Bhushan, S., Ind. J. Pure and Appl. Phys., **34**, 106, 1996.

Shrivastava, S. and Bhushan, S., Ind. J. Phys., **10** A (4), 487, 1996.

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Dispersion behavior of radio frequency waves in ion cyclotron frequency range of Aditya Tokamak plasma

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Abstract : Stix's, T. H. [1] has already derived the dispersion relation for two dimension at propagation of low frequency waves in ion cyclotron frequency range for cold as well as warm plasma. These dispersion relations have been derived for wave propagation in parallel and perpendicular direction to the magnetic field. Here we have derived a general dispersion relation for fusion plasma with hydrogen ions, electrons, and deuterium with few approximations. Theoretically we have studied the cases of angular propagation to the magnetic field within broad range of Aditya tokamak parameters. During the numerical calculation, we have considered two cases **k** || **B**o and **k** ⊥ **B**o and roots have been discussed on varying the frequency.

Key words : Ion Cyclotron Resonance Heating ; Radio Frequency Waves; Tokamak

PACS Nos. : 52.40D; 52.50; 52.65

1. Introduction

For radio frequency heating the main requirement is that it should be possible to launch a wave from the plasma edge, get coupled to the plasma, travel with minimum losses up to core and deposit the power at the required position in the plasma corresponding to the cyclotron resonance layer. Radio frequency heating falls into four major frequency ranges within which the wave excited at the edge may propagate into the central region and be absorbed in the range of ion cyclotron resonance frequencies. Having such property of radio frequency heating, we have derived a general dispersion relation of low frequency waves for a fusion plasma with α (electrons, hydrogen ions, deuterium) species. The purpose of such general dispersion relation is to see the behaviour of propagation characteristics of different low frequency modes [2,3,4]. By using the parameters of Aditya tokamak, we find the dispersion relation in the form of a polynomial with complex coefficients. Since the analytical solution is very complicated, so one can develop a computer code [5] for the solution of such complicated dispersion relation. For separation of the roots we have inserted many exiting dispersion relations in the computer code and compare the data. Through the computer code the plasma parameters as frequency, ion temperature, electron temperature, deuterium percentage, ion density, electron density, propagation angle, etc. can be varied, but for this paper we have varied only frequency.

2. Theory

The dispersion relation using fluid theory in two dimensions has been derived by Stix's, T. H. [1] with few approximations, which are as follows.

a. for thermal (warm) plasma only z-component of electric displacement vector have been taken.

b. momentum and continuity equations have been considered only for electrons.

c. inertia term in equation of motion has been neglected.

For obtaining more realistic results, we have derived dispersion relation using fluid theory in presence of hydrogen ions, electrons and deuterium [6,7]. The following momentum and continuity equations for $\alpha\alpha$ (hydrogen ions, electrons and deuterium) species in (SI units) are used as a basic equations;

$$m_\alpha n_\alpha \partial V_\alpha / \partial t = q_\alpha n_\alpha [\mathbf{E} + \mathbf{V}_\alpha \times \mathbf{B}o] - \nabla p_\alpha \qquad \ldots(1)$$

$$\nabla p_\alpha = \kappa T_\alpha \nabla n_\alpha \qquad \ldots(2), \qquad \partial n_\alpha / \partial t + \nabla . (n_\alpha V_\alpha) = 0 \qquad \ldots(3)$$

where m_α is mass, n_α is density, T_α is temperature, $\mathbf{V}_\alpha$ is velocity of α - species, **E** is electric field, **k** is propagation vector, B_o z^ is the static magnetic field along z-axis and all the symbols have their usual meanings.

For the plane wave perturbations, the space and time derivations can be transformed as

$$\partial / \partial t = - \iota \omega, \nabla = \iota \mathbf{k} \qquad \ldots(4)$$

After perturbation, linearization and solving by Cramer's rule, the equations (1), (2), (3) becomes

$$V_{\alpha x1} = A_1 / D_1 \quad \ldots(5), \qquad V_{\alpha y1} = B_1 / D_1 \quad \ldots(6), \qquad V_{\alpha z1} = C_1 / D_1 \quad \ldots(7)$$

where

$$A1 = \left[\begin{array}{lll} \iota\omega_{c\alpha}\ E_{x1}/(\omega B_0) & \{-\iota\omega c\alpha/\omega - \kappa T_\alpha k_x k_y/(m_\alpha\omega_2)\} & \{-\kappa T\alpha\, k_x k_z/(m_\alpha\omega^2)\} \\ \iota\omega_{c\alpha}\ E_{y1}/(\omega B_0) & \{1 - \kappa T_\alpha k_y^2/(m_\alpha\omega^2)\} & \{-\kappa T_\alpha k_y k_z/(m_\alpha\omega^2)\} \\ \iota\omega_{c\alpha}\ E_{z1}/(\omega B_0) & \{-\kappa T_\alpha k_y k_z/(m\alpha\omega_2)\} & \{1 - \kappa T_\alpha k_z^2/(m_\alpha\omega^2)\} \end{array}\right] \ldots(8)$$

$$B1 = \left[\begin{array}{lll} \{1 - \kappa T_\alpha k_x^2/(m_\alpha\omega^2)\} & \{\iota\omega_{c\alpha}\ Ex1/(\omega B_0)\} & \{-\kappa T_\alpha k_x k_z/(m_\alpha\omega^2)\} \\ \{\iota\omega c_\alpha/\omega - \kappa T_\alpha k_x k_y/(m_\alpha\omega^2)\} & \{\iota\omega_{c\alpha}\ E_{y1}/(\omega B_0)\} & \{-\kappa T_\alpha k_y k_z/(m_\alpha\omega^2)\} \\ \{-\kappa T_\alpha k_x k_z/(m_\alpha\omega^2)\} & \{\iota\omega_{c\alpha}\ E_{z1}/(\omega B_0)\} & \{1 - \kappa T_\alpha k_{z2}/(m_\alpha\omega^2)\} \end{array}\right] \ldots(9)$$

$$C1 = \left[\begin{array}{lll} \{1 - \kappa T\alpha\, k_x^2/(m_\alpha\omega^2)\} & \{-\iota\omega_{c\alpha}/\omega - \kappa T_\alpha k_x k_y/(m_\alpha\omega^2)\} & \{\iota\omega_{c\alpha}\ E_{x1}/(\omega B_0)\} \\ \{\iota\omega c_\alpha/\omega - \kappa T\alpha\, k_x k_y/(m_\alpha\omega^2)\} & \{1 - \kappa T_\alpha k_y^2/(m_\alpha\omega^2)\} & \{\iota\omega_{c\alpha}\ E_{y1}/(\omega B_0)\} \\ \{-\kappa T_\alpha k_x k_z/(m_\alpha\omega^2)\} & \{-\kappa T\alpha\, k_y k_z/(m_\alpha\omega^2)\} & \{\iota\omega_{c\alpha}\ E_{z1}/(\omega B_0)\} \end{array}\right] \ldots(10)$$

$$D1 = \left[\begin{array}{lll} \{1 - \kappa T_\alpha k_x^2/(m_\alpha\omega^2)\} & \{-\iota\omega_{c\alpha}/\omega - \kappa T_\alpha k_x k_y/(m_\alpha\omega^2)\} & \{-\kappa T_\alpha k_x k_z/(m_\alpha\omega^2)\} \\ \{\iota\omega_{c\alpha}/\omega - \kappa T_\alpha k_x k_y/(m_\alpha\omega^2)\} & \{1 - \kappa T_\alpha k_y^2/(m_\alpha\omega^2)\} & \{-\kappa T\alpha\, k_y k_z/(m_\alpha\omega^2)\} \\ \{-\kappa T_\alpha k_x k_z/(m_\alpha\omega^2)\} & \{-\kappa T_\alpha k_y k_z/(m_\alpha\omega^2)\} & \{1 - \kappa T_\alpha k_z^2/(m_\alpha\omega^2)\} \end{array}\right] \ldots(11)$$

The electric displacement **D** includes the vacuum displacement and the plasma current according to the relation

$$\mathbf{D} = \mathbf{K} \cdot \mathbf{E} \quad \ldots(12) \qquad \text{or} \qquad \mathbf{D} = \mathbf{E} + (\iota/\epsilon_0\omega)\mathbf{J} \quad \ldots(13)$$

where **K** is the dielectric tensor. The plasma current J is defined as

$$J = \Sigma_\alpha n_\alpha q_\alpha V_\alpha \quad \ldots(14)$$

The solution of equations (13) with the perturbed values of equations (14) is

$$\left.\begin{array}{lll} K_{xx}\ E_{x1} & = & A_{11} E_{x1} - A_{12} E_{y1} + A_{13} E_{z1} \\ K_{yy}\ E_{y1} & = - & B_{11} E_{x1} + B_{12} E_{y1} - B_{13} E_{z1} \\ K_{zz}\ E_{z1} & = & C11\, E_{x1} - C_{12} E_{y1} + C_{13}\ E_{z1} \end{array}\right] \ldots(15)$$

where

$$\left.\begin{aligned}
A_{11} &= 1 - \Sigma_\alpha [\{\omega_{p\alpha}^2/(\omega^2 D_1)\}\{1 - \kappa T_\alpha (k_y^2 + k_z^2)/(m_\alpha\omega^2)\}]\\
A_{12} &= \Sigma_\alpha [\{\omega_{p\alpha}^2/(\omega^2 D_1)\}\{\iota\omega_{c\alpha}/\omega + \kappa T_\alpha (k_x k_y - \iota\omega_{c\alpha} k_z^2/\omega)/(m_\alpha\omega^2)\}]\\
A_{13} &= -\Sigma_\alpha [\{\omega p_\alpha^2/(\omega^2 D_1)\}\{\kappa T\alpha (k_x k_z + \iota\omega_{c\alpha} k_y k_z/\omega)/(m_\alpha\omega^2)\}]\\
B_{11} &= \Sigma_\alpha [\{\omega p_\alpha^2/(\omega^2 D_1)\}\{-\iota\omega_{c\alpha}/\omega + \kappa T_\alpha (k_x k_y + \iota\omega_{c\alpha} k_{z2}/\omega)/(m_\alpha\omega^2)\}]\\
B_{12} &= 1 - \Sigma_\alpha[\{\omega_{p\alpha}^2/(\omega^2 D_1)\}\{1 - \kappa T_\alpha (k_x^2 + k_z^2)/(m_\alpha\omega^2)\}]\\
B_{13} &= \Sigma_\alpha [\{\omega_{p\alpha}^2/(\omega^2 D_1)\}\{\kappa T_\alpha (k_y k_z - \iota\omega_{c\alpha} k_x k_z/\omega)/(m_\alpha\omega^2)\}]\\
C_{11} &= -\Sigma_\alpha [\{\omega_{p\alpha}^2/(\omega^2 D_1)\}\{\kappa T_\alpha (-\iota\omega_{c\alpha} k_y k_z/\omega + k_x k_z)/(m_\alpha\omega^2)\}]\\
C_{12} &= \Sigma_\alpha [\{\omega_{p\alpha}^2/(\omega^2 D_1)\}\{\kappa T_\alpha (k_y k_z + \iota\omega_{c\alpha} k_x k_z/\omega)/(m_\alpha\omega^2)\}]\\
C_{13} &= 1 - \Sigma_\alpha [\{\omega_{p\alpha}^2/(\omega^2 D_1)\}\{1 - \omega_{c\alpha}^2/\omega^2 - \kappa T_\alpha (k_x^2 + k_y^2)/(m_\alpha\omega^2)\}]
\end{aligned}\right] \quad \ldots(16)$$

where $\omega_{p\alpha}\alpha = [n_0 q_\alpha^2 / (\in_0 m_\alpha)]^{1/2}$ (plasma frequency of α - species) ...(17)

and $\omega_{c\alpha} = q_\alpha B_0/m_\alpha$ (cyclotron frequency of α - species) ...(18)

since we know that

$\nabla \times \mathbf{E} = -\partial\mathbf{B}/\partial t$ ...(19), $\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + (1/c^2)\,\partial\mathbf{E}/\partial t$ ...(20)

are Maxwell's equations. Taking Fourier analysis in time and space of equations (19) and (20) and after solving we get

$n \times (n \times E) + K \,.\, E = 0$ ...(21), where $\mathbf{n} = c\,\mathbf{k}/\omega$ ...(22)

n is a dimensionless vector and is known as refractive index.

The matrix form of equation (21) is

$$\begin{bmatrix} A_{11} - (n_y^2 + n_z^2) & -A_{12} + nx\,ny & A_{13} + n_x n_z \\ -B_{11} + n_x n_y & B_{12} - (n_z^2 + n_x^2) & -B_{13} + n_y n_z \\ C_{11} + n_x n_z & -C_{12} + n_y n_z & C_{13} - (n_x^2 + n_y^2) \end{bmatrix} \begin{bmatrix} E_{x1} \\ E_{y1} \\ E_{z1} \end{bmatrix} = 0 \quad \ldots(23)$$

The non-trivial solution of equation (23) is given by the determinant

$$\begin{vmatrix} A_{11} - (n_y^2 + n_z^2) & -A_{12} + n_x n_y & A_{13} + n_x n_z \\ -B_{11} + n_x n_y & B_{12} - (n_z^2 + n_x^2) & -B_{13} + n_y n_z \\ C_{11} + n_x n_z & -C_{12} + n_y n_z & C_{13} - (n_x^2 + n_y^2) \end{vmatrix} = 0 \quad \ldots(24)$$

The solution of equations (24) is

$$
\begin{gathered}
[(n_y^2 + n_z^2) \{(n_x^2 + n_y^2) B_{12} + (n_z^2 + n_x^2) C_{13}\} - (n_y^2 + n_z^2) (C_{12} n_y n_z + B_{13} n_y n_z) - n_x^2 n_y^2 \\
C_{13} - n_x n_y (n_x^2 + n_y^2) B_{11} - n_x^2 n_y n_z B_{13} + n_x n_y^2 n_z C_{11} - n_x^2 n_y n_z C_{12} - n_x n_y n_z^2 B_{11} - n_x^2 \\
n_z^2 B_{12} + n_x n_z (n_z^2 + n_x^2) C_{11} - A_{11} n_y^2 n_z^2 + A_{11} (n_z^2 + n_x^2) (n_x^2 + n_y^2) - A_{12} n_x n_y (n_x^2 + \\
n_y^2) - A_{12} n_x n_y n_z^2 + A_{13} n_x n_y^2 n_z + A_{13} n_x n_z (n_z^2 + n_x^2)] + [A_{11} \{- (n_x^2 + n_y^2) B_{12} - (n_z^2 + \\
n_x^2) C_{13} + C_{12} n_y n_z + B_{13} n_y n_z\} -(n_y^2 + n_z^2) B_{12} C_{13} + (n_y^2 + n_z^2) B_{13} C_{12} + A_{12} \{n_x n_y C_{13} \\
+ B_{11} (n_x^2 + n_y^2) + n_x n_z B_{13} - C_{11} n_y n_z\} - n_x n_y (- B_{11} C_{13} + C_{11} B_{13}) + A_{13} \{- C_{12} n_x n_y - B_{11} \\
n_y n_z - n_x n_z B_{12} + C_{11} (n_z^2 + n_x^2)\} + n_x n_z (B_{11} C_{12} - C_{11} B_{12})] + [A_{11}\{B_{12} C_{13} - B_{13} C_{12}\} + \\
A_{12}\{- B_{11} C_{13} + C_{11} B_{13}\} + A_{13} \{B_{11} C_{12} - C_{11} B_{12}\}] = 0 \qquad \ldots(25)
\end{gathered}
$$

Let $n_x^2 + n_y^2 = \alpha = n^2 \alpha_1$ where $\alpha_1 = (\sin^2\theta \sin^2\phi + \cos^2\theta)$

$n_y^2 + n_z^2 = \beta = n^2 \beta_1$ where $\beta_1 = (\sin^2\theta \cos^2\phi + \cos^2\theta)$

$n_z^2 + n_x^2 = \gamma = n^2 \gamma_1$ where $\gamma_1 = \sin^2\theta$

and $n_x n_y = n_2 Q_1$ where $Q_1 = \sin\theta \cos\theta \sin\phi$

$n_y n_z = n_2 Q_2$ where $Q_2 = \sin\theta \cos\theta \cos\phi$

$n_x n_z = n_2 Q_3$ where $Q_3 = \sin^2\theta \sin\phi \cos\phi$

where, θ is angle between y-axis and propagation vector k and ϕ is angle between z-axis and the projection of the propagation vector in x-z plane.

Substituting all these values in equation (25) we get

$$
\begin{gathered}
n^4 [A_{11} (\alpha_1 \gamma_1 - Q_2^2) - A_{12} (Q_1 \alpha_1 + Q_2 Q_3) + A_{13} (Q_1 Q_2 + Q_3 \gamma_1) - B_{11} (\alpha_1 Q_1 + Q_2 Q_3) + B_{12} \\
(\alpha_1 \beta_1 - Q_3^2) - B_{13} (\beta_1 Q^2 + Q_1 Q_3) + C_{11} (Q_1 Q_2 + \gamma_1 Q_3) - C_{12} (\beta_1 Q_2 + Q_1 Q_3) + C_{13} (\beta_1 \gamma_1 - Q_{12}) \\
+ n^2 [A_{11} (- \alpha_1 B_{12} - \gamma_1 C_{13} + C_{12} Q_2 + B_{13} Q_2) + (B_{13} C_{12} - C_{13} B_{12}) \beta_1 + A_{12} (Q_1 C_{13} + B_{11} \alpha_1 + \\
Q_3 B_{13} - Q_2 C_{11}) + (B_{11} C_{13} - C_{11} B_{13}) Q_1 + A_{13} (-Q_1 C_{12} - Q_2 B_{11} - Q_3 B_{12} + C_{11} \gamma_1) + (B_{11} C_{12} \\
- C_{11} B_{12}) Q_3] + [A_{11} (B_{12} C_{13} - B_{13} C_{12}) + A_{12} (B_{13} C_{11} - B_{11} C_{13}) + A_{13} (B_{11} C_{12} - C_{11} B_{12})] = 0 \\
\ldots(26)
\end{gathered}
$$

Consider the term

$$\Sigma_\alpha [\omega_{p\alpha}^2 /(\omega^2 D_1)] = \Sigma_\alpha [\omega_{p\alpha}^2 /\{\omega^2 \{1 - \omega_{c\alpha}^2/\omega^2 - \kappa T_\alpha (k^2 - \omega_{c\alpha}^2 k_z^2 /\omega^2)/(m_\alpha \omega^2)\}\}] \qquad \ldots(26)(a)$$

Assuming TiH = 0, TiD = 0. then above equation (26)(a) reduces as

$$\sum_{\alpha} [\omega_{p\alpha}{}^{2}/(\omega_{2}\ D_{1})] = \omega_{piH}{}^{2} / T_{1} + \omega_{piD}{}^{2} / U_{1} + \omega_{pe}{}^{2} / (P_{1} - n_{2}\ P_{2})$$

$$= (E_{1} - n_{2}\ E_{2})/\{T_{1}\ U_{1}\ (P_{1} - n_{2}\ P_{2})\} \qquad ...(27)$$

where symbols '$_{iH}$' for ions, '$_{iD}$' for deuterium and '$_{e}$' for electrons

$T_{i} = (\omega^{2} - \omega_{ciH}{}^{2})$, $\quad U_{1} = (\omega^{2} - \omega_{ciD}{}^{2})$, $\quad b3 = \kappa\kappa Te\ /me$

$P_{1} = (\omega^{2} - \omega_{ce}{}^{2})$, $\quad P^{2} = (b_{3}\ /\ c^{2})\ (\omega^{2} - \omega_{ce}{}^{2}\ Z_{1}{}^{2}\ Z_{4}{}^{2})$,

$E_{1} = U_{1}\ P_{1}\ \omega_{piH}{}^{2} + T_{1}\ P_{1}\ \omega_{piD}{}^{2} + T_{1}\ U_{1}\ \omega_{pe}{}^{2}$

$E_{2} = U_{1}\ P_{2}\ \omega_{piH}{}^{2} + T_{1}\ P_{2}\ \omega_{piD}{}^{2}$

$Z_{1} = \sin\theta$, $\quad Z_{2} = \cos\theta$, $\quad Z_{3} = \sin\phi$, $\quad Z_{4} = \cos\phi$

Substituting all these values in A_{11} to C_{13} and solving we get

$A_{11} = (n^{2}\ V_{1} + V_{2})\ /WW$, $\quad A_{12} = (n^{2}\ V_{3} + V_{4})\ /WW$, $\quad A_{13} = n^{2}\ P_{5}\ /\ WW$,
$B_{11} = (n^{2}\ V_{5} + V_{6})\ /\ WW$, $\quad B_{12} = (n^{2}\ V_{7} + V_{2})\ /\ WW$, $\quad B_{13} = n^{2}\ P_{8}\ /\ WW$,
$C_{11} = n^{2}\ P_{9}\ /\ WW$, $\quad C_{12} = n^{2}\ P_{10}\ /\ WW$, $\quad C_{13} = (n^{2}\ V_{8} + V_{9})\ /\ WW$

where

$V_{1} = [- E_{3}\ P_{2} + \omega_{pe}{}^{2}\ P_{3}]$, $\quad V_{2} = [\ E_{3}\ P_{1} - \omega_{pe}{}^{2}\ ]$, $\quad V_{3} = [- E_{4}\ P_{2} + \omega_{pe}{}^{2}\ P_{4}]$

$V_{4} = [\ E_{4}\ P_{1} + \iota\omega_{pe}{}^{2}\ R_{3}]$, $\quad V_{5} = [\ E_{4}\ P_{2} + \omega_{pe}{}^{2}\ P_{6}]$, $\quad V_{6} = [- E_{4}\ P_{1} - \iota\ \omega_{pe}{}^{2}\ R_{3}]$

$V_{7} = [- E_{3}\ P_{2} + \omega_{pe}{}^{2}\ P_{7}]$, $\quad V_{8} = [- E_{5}\ P_{2} + \omega_{pe}{}^{2}\ P_{11}]$, $\quad V_{9} = [\ E_{5}\ P_{1} - \omega_{pe}{}^{2}\ P_{12}]$

$E_{3} = [\ T_{1}\ U_{1} - \omega_{piH}{}^{2}\ U_{1} - \omega_{piD}{}^{2}\ T_{1}]\ /\ (T_{1}\ U_{1})$

$E_{4} = \iota\ [U_{1}\ R_{1}\ \omega_{piH}{}^{2} + R_{2}\ T_{1}\ \omega_{piD}{}^{2}\ ]\ /\ (T_{1}\ U_{1})$

$E_{5} = [T_{1}\ U_{1} - U_{1}\ (1 - R_{1}{}^{2})\ \omega_{piH}{}^{2} - T_{1}(1 - R_{2}{}^{2})\ \omega_{piD}{}^{2}\ ]\ /\ (T_{1}\ U_{1})$

$P_{3} = (b_{3}\ \beta_{1})\ /c^{2}$, $P_{4} = b_{3}\ (QQ_{1} - \iota\ R_{3}\ Q_{4})\ /c^{2}$, $\quad P_{5} = - \omega_{pe}{}^{2}\ b_{3}\ (QQ_{3} + \iota\ R_{3}\ Q_{2})\ /c^{2}$.

$P_{6} = b_{3}\ (QQ_{1} + \iota\ R_{3}\ Q_{4})\ /c^{2}$, $P_{7} = b_{3}\ \gamma_{1}\ /c^{2}$, $\quad P_{8} = \omega_{pe}{}^{2}\ b_{3}\ (QQ_{2} - \iota\ R_{3}\ Q_{3})\ /c^{2}$.

$P_{9} = - \omega_{pe}{}^{2}\ b_{3}\ (QQ_{3} - \iota\ R_{3}\ Q_{2})\ /c^{2}$, $\quad P_{10} = \omega_{pe}{}^{2}\ b_{3}\ (QQ_{2} + \iota\ R_{3}\ Q_{3})\ /c^{2}$

$P_{11} = b_{3}\ \alpha_{1}\ /c^{2}$, $\quad P_{12} = 1 - R_{3}{}^{2}$,

$R_{1} = \omega_{ciH}\ /\ \omega$, $\quad R_{2} = \omega_{ciD}\ /\ \omega$, $\quad R_{3} = \omega_{ce}\ /\ \omega$,

QQ_1 = complex of (Q_1), QQ_2 = complex of (Q_2),

QQ_3 = complex of (Q_3), QQ_4 = complex of (Q_4),

$Q_4 = \sin^2\theta \cos^2\phi$, $WW = (P_1 - n^2 P_2)$

Let

$W_1 = \alpha_1 \beta_1 - Q_3^2$, $W_2 = \beta_1 \gamma_1 - Q_1^2$, $W_3 = \beta_1 Q_2 + Q_1 Q_3$,

$W_4 = \beta_1 Q_2 + Q_1 Q_3$, $W_5 = \alpha_1 Q_1 + Q_2 Q_3$, $W_6 = Q_1 Q_2 + \gamma_1 Q_3$,

$W_7 = Q_2^2 - \alpha_1 \gamma_1$, $W_8 = \alpha_1 Q_1 + Q_2 Q_3$, $W_9 = Q_1 Q_2 + Q_3 \gamma_1$

Substituting W_1 to W_9 and A_{11} to C_{13} in equation (26) and solving for refractive index, we find a polynomial

$$n^{10} VV_1 + n^8 VV_2 + n^6 VV_3 + n^4 VV_4 + n^2 VV_5 + VV_6 = 0 \qquad \ldots(28)$$

where

$VV_1 = FF_{17}$, $VV_2 = [FF_{18} - P_2 FF_{21}]$, $VV_3 = [FF_{19} - P_2 FF_{22} + P_1 FF_{21} + FF_{24}]$,

$VV_4 = [FF_{20} - P_2 FF_{23} + P_1 FF_{22} + FF_{25}]$, $VV_5 = [FF_{26} + P_1 FF_{23}]$, $VV_6 = [FF_{27}]$

$FF_1 = W_1 V_7 + W_2 V_8 - W_3 P_{10} - W_4 P_8 - W_5 V_5 + W_6 P_9 - W_7 V_1 - W_8 V_3 + W_9 P_5$

$FF_2 = W_1 V_2 + W_2 V_9 - W_5 V_6 - W_7 V_2 - W_8 V_4$

$FF_3 = -\alpha_1 V_7 - \gamma_1 V_8 + Q_2 P_{10} + Q_2 P_8$

$FF_4 = -\alpha_1 V_2 - \gamma_1 V_9$, $FF_5 = Q_1 V_8 + \alpha_1 V_5 + Q_3 P_8 - Q_2 P_9$.

$FF_6 = Q_1 V_9 + \alpha_1 V_6$, $FF_7 = -Q_1 P_{10} - Q_2 P_5 - Q_3 V_7 + \gamma_1 P9$,

$FF_8 = -Q_2 V_6 - Q_3 V_2$, $FF_9 = V_7 V_8 - P_8 P_{10}$,

$FF_{10} = V_7 V_9 + V_2 V_8$, $FF_{11} = V_2 V_9$,

$FF_{12} = P_8 P_9 - V_5 V_8$, $FF_{13} = -V_5 V_9 - V_6 V_8$, $FF_{14} = -V_6 V_9$,

$FF_{15} = P_{10} V_5 - P_9 V_7$, $FF_{16} = P_{10} V_6 - P_9 V_2$, $FF_{17} = EE_1 FF_1$,

$FF_{18} = EE_1 FF_2 + EE_2 FF_1$, $FF_{19} = EE_2 FF_2 + EE_3 FF_1$, $FF_{20} = EE_3 FF_2$,

$FF_{21} = V_1 FF_3 + (P_8 P_{10} - V_8 V_7) \beta_1 + V_3 FF_5 + (V_5 V_8 - P_8 P_9) Q_1 + P_5 FF_7 + (V_5 P_{10} - P_9 V_7) Q_3$

$FF_{22} = V_1 FF_4 + V_2 FF_3 - (V_8 V_2 + V_9 V_7) \beta_1 + V_3 FF_6 + V_4 FF_5 + (V_5 V_9 + V_6 V_8) Q_1 + P_5 FF_8 + (V_6 P_{10} - V_2 V_9) Q_3$

$FF_{23} = V_2 FF_4 - V_9 V_2 \beta_1 + V_4 FF_6 + V_6 V_9 Q_1$

$FF_{24} = V_1 FF_9 + V_3 FF_{12} + P_5 FF_{15}$

$FF_{25} = V_1 FF_{10} + V_2 FF_9 + V_3 FF_{13} + V_4 FF_{12} + P_5 FF_{16}$

$FF_{26} = V_1\ FF_{11} + V_2\ FF_{10} + V_3\ FF_{14} + V_4\ FF_{13}$

$FF_{27} = V_2\ FF_{11} + V_4\ FF_{14}$

$EE_1 = P_2^2$, $EE_2 = - 2\ P_1\ P_2$, $EE_3 = P_1^2$

Since the analytical solution of equation (28) is very complicated, so we have solved it numerically. If the coefficients of the polynomial have much differences in the degree, then the roots have been mixed. For avoiding this error we have inserted many existing dispersion relations and compared the data of actual roots with the data of standard dispersion relations. During comparison we have ignored 1% data matching error. If the data does not match with the data of existing dispersion relations, then such data have been inserted in separate data files called as else roots (extra roots). Numerically we have discussed the roots for two cases (1). $\mathbf{k} \parallel \mathbf{B}_0$ and (2). $\mathbf{k} \perp \mathbf{B}_0$

3. Aditya Tokamak Parameters (1989):

Major radius = 0.75 m, Minor radius = 0.25 m

Toroidal magnetic field = 1.5 T, Deuterium percentage = 0.05

Maximum Te = 300.0 eV, Minimum Te = 20.0 eV

$n_{iH} = 2.25 \times 10^{19}\ m^{-3}$, $n_{iD} = 2.25 \times 10^{19}\ m^{-3}$, $n_e = 2.25 \times 10^{19}\ m^{-3}$

Applied radio frequency at center of the device = 34.4047068 x 10^6 Hz. This frequency varies as

series 1 (1.0 ω_{ciH}) = 22936472.3006 Hz , series 2 (1.5 ω_{ciH}) = 34.4047068 x 10^6 Hz

series 3 (2.0 ω_{ciH}) = 45872944.0010 Hz , series 4 (1.0 ω_{piH}) = 19.8541090 x 10^8 Hz

Plots : Sr. No. (1 - 8) for $\mathbf{k} \parallel \mathbf{B}_o$

[1].

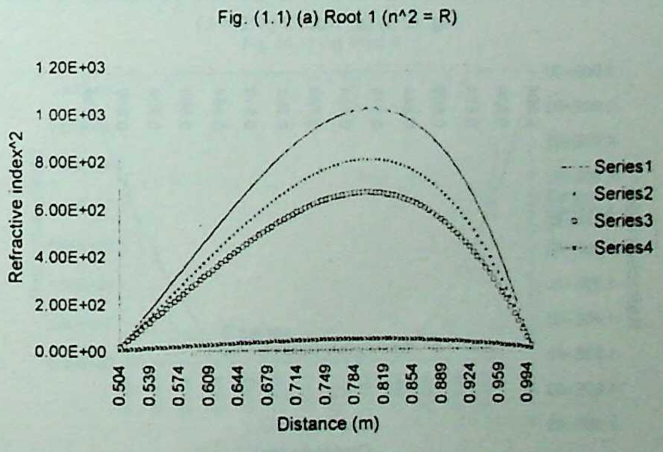

Fig. (1.1) (a): Root 1 (n^2-R) of the polynomial for series 1, series 2, series 3, series 4

(2)

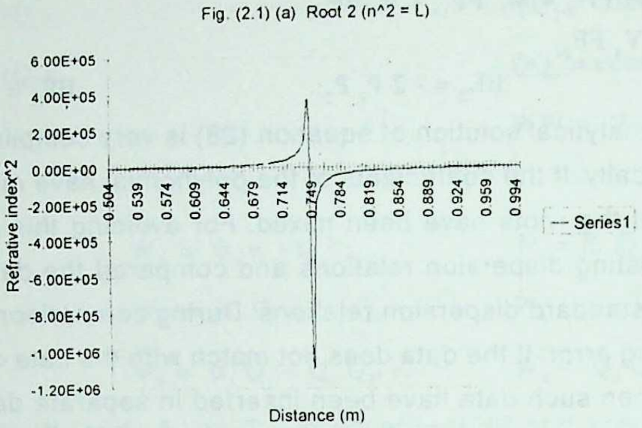

Fig. (2.1) (a) : Root2 (n^2=L) of the polynomial for series 1.

(3)

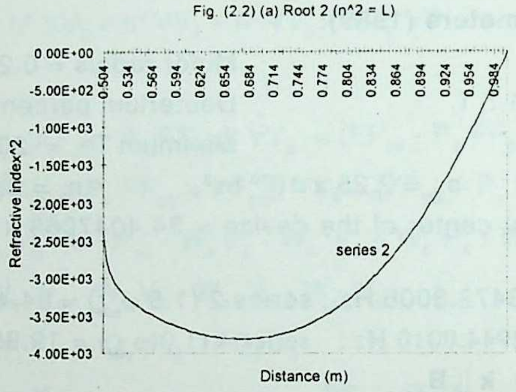

Fig. (2.2) (a) : Root2 (n^2=L) of the polynomial for series 2.

(4)

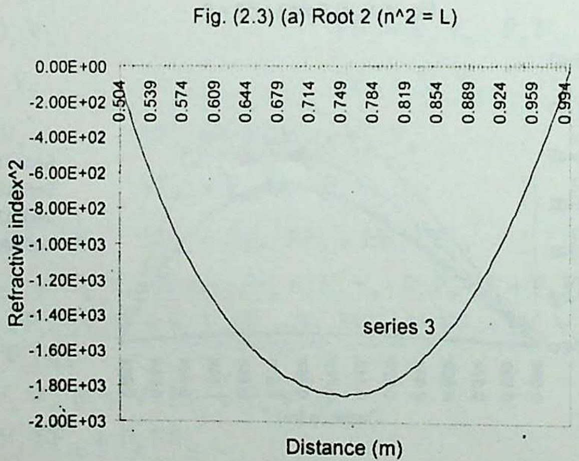

Fig. (2.3) (a) : Root2 (n^2=L) of the polynomial for series 3.

(5)

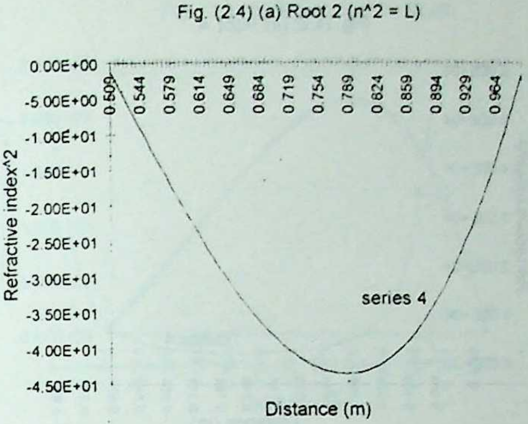

Fig. (2.4) (a) : Root2 (n^2=L) of the polynomial for series 4.

(6)

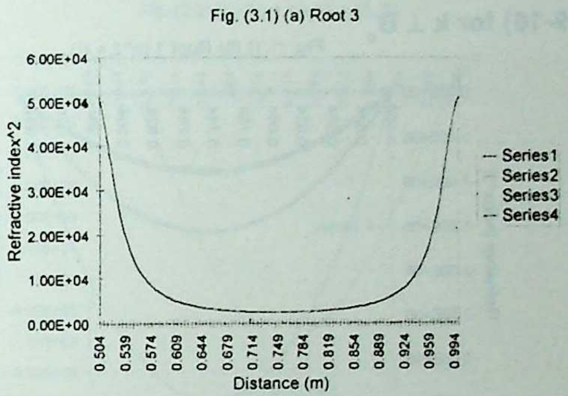

Fig. (3.1) (a) : Root 3 due to multiplication factor (P_1-n^2 P_2) of the polynomial for series 1, series 2, series 3, series 4. (Data for all the series approximately be same)

(7)

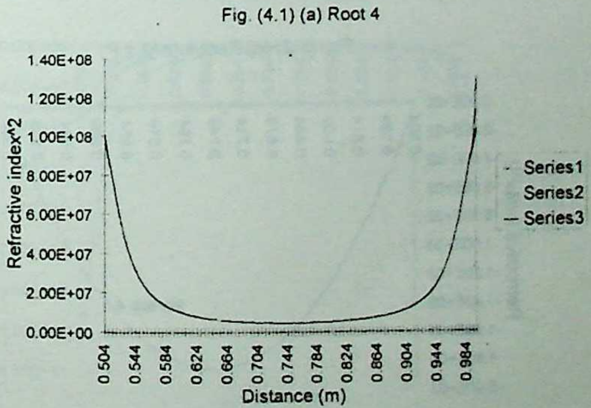

Fig. (4.1) (a) : Root 4 due to data exist in else roots of the polynomial for series 1, series 2, series 3. (Data for all the series approximately be same)

(8)

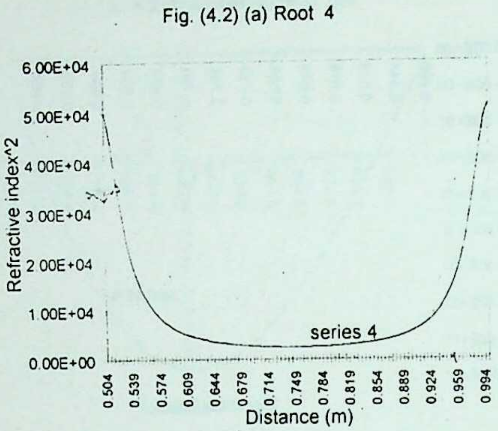

Fig. (4.2) (a) : Root4 due to data exist in else roots of the polynomial for series 4.

Plots : Sr. No. (9-16) for k ⊥ B_o

(9)

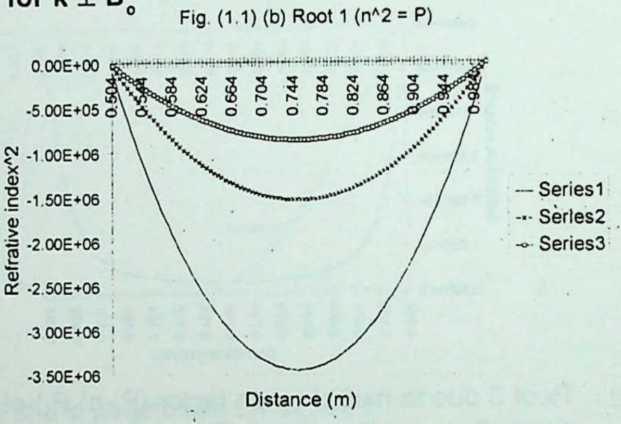

Fig. (1.1) (b) : Root 1 (n^2=P) of the polynomial for series 2, series 3.

(10)

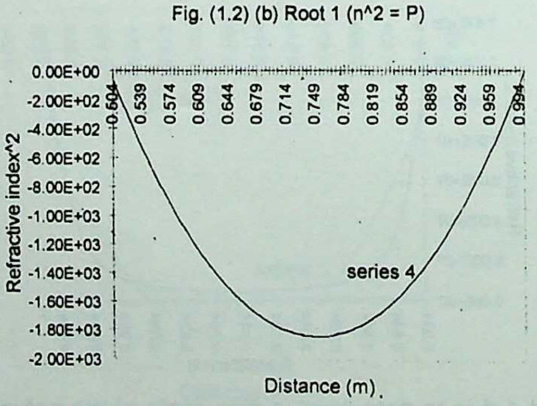

Fig. (1.2) (b) : Root 1 (n^2=P) of the polynomial for series 4.

(11)

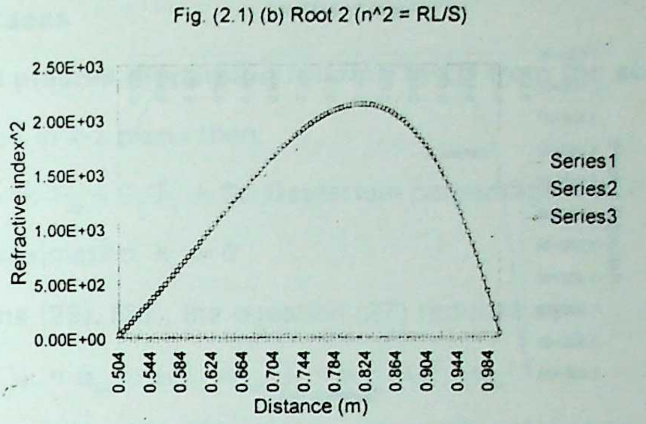

Fig. (2.1) (b) : Root 1 ($n^2 = RL / S$) of the polynomial for series 1, series 2, series3.

(12)

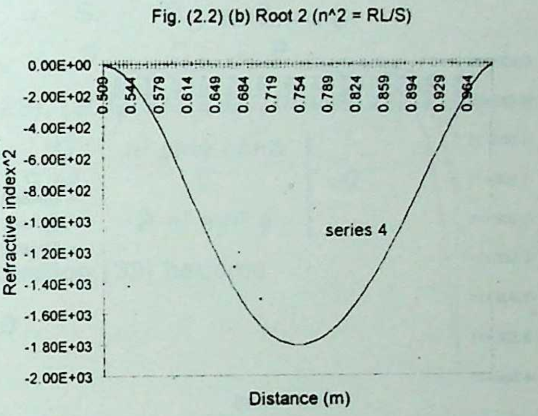

Fig. (2.2) (b) : Root 1 ($n^2 = RL / S$) of the polynomial for series 4.

(13)

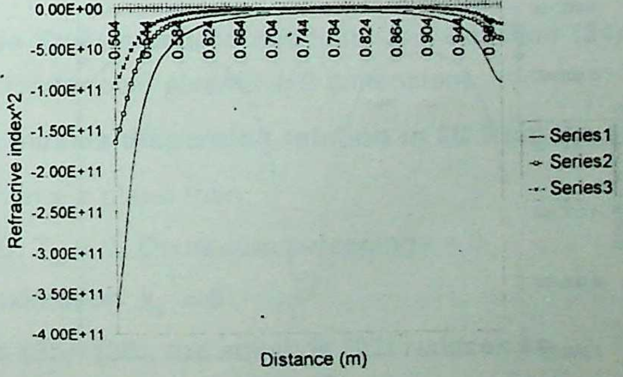

Fig. (3.1) (b) : Root 3 due to multiplication factor ($P_1 - n^2 P_2$) of the polynomial for series 1, series 2, series 3.

(14)

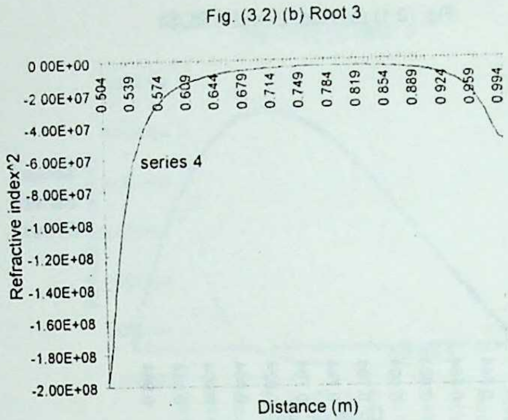

Fig. (3.2) (b) : Root 3 due to multiplication factor (P_1 - n^2 P_2) of the polynomial for series 4.

(15)

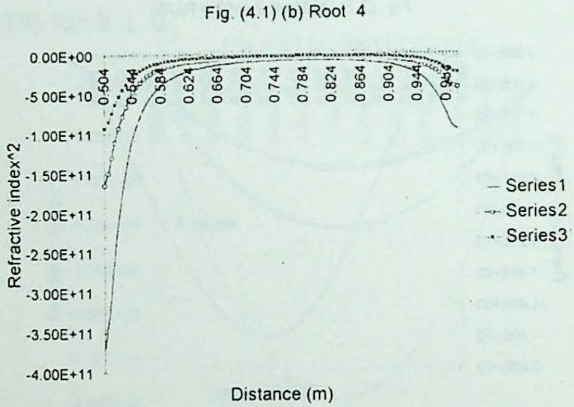

Fig. (4.1) (b) : Root 4 due to data exist in else roots of the polynomial for series 1, series 2, series 3.

(16)

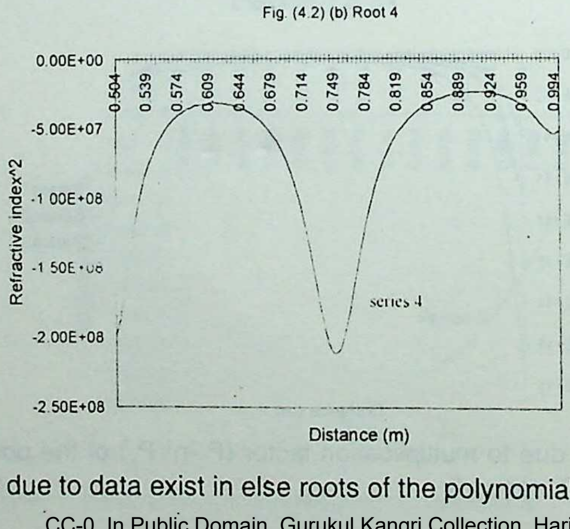

Fig. (4.2) (b) : Root 4 due to data exist in else roots of the polynomial for series 4.

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4. Li

Case

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4. Limiting Cases

Case 1: Cold plasma dispersion relation in 2D from the above analysis

Let propagation in x-z plane then,

$\theta = 90°$, $T_{iH} = 0$, $T_{iD} = 0$, $T_e = 0$, Deuterium percentage = 0 ...(29)

taking an approximation $k_x = 0$ ...(30)

using equations (29), (30), the equation (27) reduces as

$$\sum_\alpha [\omega_{p\alpha}^2/(\omega^2 D_1)] = \omega_{piH}^2/(\omega^2 - \omega_{ciH}^2) + \omega_{pe}^2/(\omega^2 - \omega_{ce}^2) \qquad ...(31)$$

using equations (29), (30), (31), the equation (16) reduces as

$$\begin{array}{lll} A_{11} = S, & A_{12} = iD, & A_{13} = 0 \\ B_{11} = -iD, & B_{12} = S, & B_{13} = 0 \\ C_{11} = 0, & C_{12} = 0, & C_{13} = P \end{array} \qquad ...(32)$$

using equations (29), (30), (31), (32), the equation (24) reduces as

$$\begin{vmatrix} S-n^2\cos^2\phi & -iD & n^2\sin\phi\cos\phi \\ iD & S-n^2 & 0 \\ n^2\sin\phi\cos\phi & 0 & P-n^2\sin^2\phi \end{vmatrix} = 0 \qquad ..(33)$$

The solution of equation (33) become

$$A\,n^4 - Bn^2 + C = 0 \qquad ...(34)$$

where

$A = S\sin^2\phi + P\cos^2\phi$

$B = RL\sin^2\phi + PS\,(1+\cos^2\phi)$

$C = PRL$

S, D, R, L, P be Stix's standard notations and equation (34) be Stix's standard dispersion relation for cold plasma in 2 dimensions.

Case 2: Warm plasma dispersion relation in 2D from the above analysis

Let propagation in x-z plane then,

$\theta = 90°$, $T_{iH} = 0$, $T_{iD} = 0$, Deuterium percentage = 0 ...(35)

taking an approximation $k_x = 0$ ...(36)

using equations (35), (36), the equation (27) reduces as

$$\Sigma\alpha\,[\omega_{p\alpha}^2/(\omega^2 D_1)] = \sum_\alpha [\omega_{p\alpha}^2/\{(\omega^2 - \omega_{c\alpha}^2)(1 - \kappa T_\alpha k_z^2/(m_\alpha\omega^2))\}] \qquad ...(37)$$

using equations (35), (36), (37), the equation (16) reduces as

$$\begin{array}{lll} A_{11} = S, & A_{12} = iD, & A_{13} = 0 \\ B_{11} = -iD, & B_{12} = S, & B_{13} = 0 \\ C_{11} = 0, & C_{12} = 0, & C_{13} = P^{**} \end{array} \qquad \ldots(38)$$

using equations (35), (36), (37) and (38), the equation (24) reduces as

$$\begin{vmatrix} S - n^2 \cos^2 \phi & -iD & n^2 \sin \phi \cos \phi \\ iD & S - n^2 & 0 \\ n^2 \sin \phi \cos \phi & 0 & P^{**} - n^2 \sin^2 \phi \end{vmatrix} = 0 \qquad \ldots(39)$$

where

$P^{**} = P_i + (P^* / (n^2 \cos^2 \phi))$

$P_i = 1 - \omega_{piH}^2 / \omega^2$

$P^* = c^2 / (\lambda_D^2 \omega^2)$

$\lambda_D = [\epsilon_o \kappa T_e / (ne\, qe^2)]^{1/2}$ (Debye length)

The solution of equation (39) become

$$a n^6 - b n^4 + c n^2 - d = 0 \qquad \ldots(40)$$

where

$a = S \sin^2 \phi \cos^2 \phi + P_i \cos^4 \phi$

$b = RL \sin^2 \phi \cos^2 \phi + P_i S (1 + \cos^2 \phi) \cos^2 \phi - P^* \cos^2 \phi$

$c = P_i RL \cos^2 \phi - P^* S (1 + \cos^2 \phi)$

$d = -P^* RL$

S, D, R, L, P be Stix's standard notations and equation (40) be Stix's standard dispersion relation for warm plasma in 2 dimensions.

5. Conclusions

In this paper, a theoretical derivation for the roots of the polynomial has been done. During the theoretical analysis it has been found that the multiplicative factor WW i.e. $(P_1 - n^2 P_2)$ provides duplicate roots in n^2 which depend upon temperature. For limiting case of cold plasma, the analysis converted into two roots in n^2. These roots exactly matches with Stix (1984) standard dispersion relation in 2 dimensions for cold plasma, which are transverse right circularly polarized wave ($n^2 = R$) and transverse left circularly polarized wave ($n^2 = L$) for propagation parallel to the magnetic field, while ordinary ($n^2 = P$) and extra ordinary mode ($n^2 = RL/S$) for propagation perpendicular to the magnetic field.

Similarly the limiting case analysis for warm plasma provides a exact dispersion relation as derived by Stix (1984) for warm plasma, which having cold as well as electrostatics modes.

For **k** || $\mathbf{B}_0$ the figure Sr. No. 8 having approximately same data as figure Sr. No. 6 and the figure Sr. No. 7 having approximately same shape as figure Sr. No. 6 but the data's having difference in the cubic degree of tenth, which shows that the else roots also depend upon temperature.

For **k** ⊥ **B**o the figure Sr. No. 15 having approximately same data as figure Sr. No. 13 and the figure Sr. No. 16 having peak negative value at the centre of the device. Thus these else roots are also depend upon temperature.

Since there is no dispersion relation whose data exactly matches with these else roots. Thus it may be said that these else roots are spurious roots. All the roots have been calculated on varying the frequency for obtaining more appropriate values. After seeing the plots it has been found that the plots for series 2 and series 3 are more appropriate, so for further analysis the data through series 1 and series 4 may be neglected.

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References

Stix, T.H., Theory of Plasma Waves, Mc-Graw Hill, New York, 1962.

W N -C Sy, Amano, T., Ando, R., Fukuyama, A. and Watari, T., Nuclear Fusion, Vol. **25**, No.7, p 795 1985.

Stix, T.H., *Waves in Plasma: Some Historical Highlights*, PPPL - 2139, August 1984.

Swanson, D.G., *Plasma Waves*, Harcourt Brace Javanovich Publishers, 1989.

Press, W.H.,*Numerical Recipes in FORTRAN*, Cambridge University Press, 1993.

Stix,T.H., Swanson, D G *Propagation and Mode Conversion for Waves in Non-uniform Plasmas*, PPPL-1903, June 1982.

Swanson, D.G., *Mode Conversion and Absorption in a Deuterium Plasma with a Hydrogen Impurity*, Proceeding of Third Topical Conference on Radio Frequency Heating, Pasadena, California, Jan. 11- 13, 1978.

Bhatt, S.N., *Aditya : The First Indian Tokamak*, Indian Journal of pure and Applied Physics, 27 (1989), p 710

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An alternative proof of Szegö type relation for the set $\{Kn\ (\alpha,\beta,k;x)\}$

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Abstract : Madhekar and Thakare defined and studied biorthogonal polynomials $\{Jn(\alpha,\beta,k;x)\}$ and $\{Kn(\alpha,\beta,k;x)\}$ suggested by Jacobi polynomials. In present note we give an alternative proof of Szegö type relation for $\{Kn(\alpha,\beta,k;x)\}$

Key words : Biorthogonal polynomials, Szegö type relation.

1. Introduction

Madhekar and Thakare (1983) studied the following pair of polynomial sets that are biorthogonal with respect to the Jacobi weight function $(1-x)^\alpha(1+x)^\beta$ over the interval (-1,1)

(1.1) $J_n(\alpha,\beta,k;x)$

$$= \frac{(1+a)kn}{n!} \sum_{j=o}^{n} (-1)^j \begin{bmatrix} n \\ j \end{bmatrix} \frac{(1+\alpha+\beta+n)_{kj}}{(1+\alpha)_{kj}} \left(\frac{1-x}{2}\right)^{kj}$$

(1.2) $K_n\ (\alpha,\beta,k;x)$.

$$= \sum_{r=0}^{n} \sum_{s=0}^{r} (-1)^{r+s} \begin{bmatrix} r \\ s \end{bmatrix} \frac{(1+\beta)_n}{n!\ r!\ (1+\beta)_{n-r}}$$

$$\left(\frac{s+\alpha+1}{k}\right)_n \left(\frac{x-1}{2}\right)^r \left(\frac{x+1}{2}\right)^{n-r}$$

Through series of papers, Thakare and Madhekar (1983, 1984, 1986, 1989) obtained various proofs of biorthogonality, generating functions and multilinear generating functions of these pairs. Here, we note the following generating functions of biorthogonal polynomial set of second kind.

(1.3) $$\sum_{n=0}^{\infty} K_n(\alpha, \beta- n, k: x)\, t^n = \left(1-\frac{x+1}{2}t\right)^{-(\alpha+1)/k}\left[1+\frac{x-1}{x-1}\left\{\left(1-\frac{x-1}{2}t\right)^{-1/k}-1\right\}\right]^{\beta}$$

(1.4) $$\sum_{n=0}^{\infty} K_n(\alpha - kn, \beta- n, k; x)t^n = \left(\frac{X+1}{2}\right)^{-\beta}\left(1+\frac{X+1}{2}t\right)^{(\alpha+1-k)/k}\left[1+\frac{X-1}{2}\left(1+\frac{X+1}{2}t\right)^{1/k}\right]^{\beta}$$

In present note we give an alternative proof of Szegö type relation for the set $\{K_n(\alpha,\beta,k:x)\}$

2. Szegö type relation for $\{K_n(\alpha,\beta,k;x)\}$:

In this section we obtain Szego type relation for biorthogonal polynomial set $\{K_n(\alpha,\beta,k:x)\}$.

(2.1) $$\{K_n(\alpha,\beta,k:x)\} = \left(\frac{1-x}{2}\right)^n K_n\left(- a - \beta - n - n k + k - 2, b, k; \frac{3+x}{x-1}\right)$$

Proof of (2.1) :

Replacing x by (3 + x) / (x - 1) and t by {(1-x) / 2} in (1.3) we obtain

$$(2.2)\quad \sum_{n=0}^{\infty}\left(\frac{1-x}{2}\right)^{n} K_{n}\,[\alpha,\ \beta-n,\ k;\ (3+x)\,/\,(x-1)]\ t^{n}$$

$$=\left(1+\frac{x+1}{2}t\right)^{-(\alpha+1)/k}\left(1+\frac{x+1}{2}t\right)^{-\beta/k}$$

$$\left[\left(1+\frac{x+1}{2}t\right)^{1/k}+\frac{2}{x+1}-\frac{2}{x+1}\left(1+\frac{x+1}{2}t\right)^{1/k}\right]^{\beta}$$

$$=\left(1+\frac{x+1}{2}t\right)^{-(\alpha+\beta+1)/k}$$

$$\left[1+\frac{x-1}{x-1}\left\{\left(1+\frac{x+1}{2}t\right)^{-1/k}-1\right\}\right]^{\beta}$$

The generating function (1.4) is written in the form

$$(2.3)\quad \sum_{n=0}^{\infty} K_{n}\,(\alpha-kn,\ \beta-n,\ k;x)\ t^{n}$$

$$=\left(1+\frac{x+1}{2}t\right)^{-(\alpha+1-k)/k}$$

$$\left[1+\frac{x-1}{x+1}\left\{\left(1+\frac{x+1}{2}\,t\right)^{1/k}-1\right\}\right]^{\beta}$$

Replace α by $-\alpha-\beta-2+k$ in (2.3)

$$(2.4)\quad \sum_{n=0}^{\infty} K_n(-\alpha-\beta-2+k-kn,\ \beta-n,\ k;\ x)t^n$$

$$=\left(1+\frac{x+1}{2}\,t\right)^{-(\alpha+\beta+1)/k}$$

$$\left[1+\frac{x-1}{x-1}\left\{\left(1+\frac{x+1}{2}\,t\right)^{1/k}-1\right\}\right]^{\beta}$$

Right hand sides of (2.2) and (2.4) are equal

$$(2.5)\quad \sum_{n=0}^{\infty}\{(1-x)/2\}^n K_n(\alpha,\ \beta-n,k;\ (3+x)/(x-1))\ t^n$$

$$=\sum_{n=0}^{\infty} K_n(-\alpha-\beta-2+k-kn,\ \beta-n,\ k;\ x)\ t^n$$

Equating coefficients of t^n on both sides

$$(2.6)\quad \{(1-x)/2\}^n K_n(\alpha,\ \beta-n,k;\ (3+x)/(x-1))$$

$$=K_n(-\alpha-\beta-2+k-kn,\ \beta-n,\ k;\ x)\ t^n$$

Replace $(3+x)/(x-1)$ by x and β by $\beta+n$ to get (2.1)

The Szegö type relation (2.1) is obtained by Madhekar (1987) by using markedly different technique.

For $k = 1$, (2.1) reduces to the Szegö type equation for Jacobi polynomials $P_n(\alpha, \beta ; x)$

(2.7) $P_n(\alpha, \beta ; x) = \{(1-x) / 2\}^n P_n(-\alpha - \beta - n, k; (3+x)/(x-1))$

References

Madhekar, H.C. and Thakare, N.K., Pacific J. Math., **8**, 417-424, 1983.

Madhekar, H.C. and Thakare, N.K., Pure Appl. Math., **15**(2), 17-24, 1984.

Thakare, N.K. and Madhekar, H. C., Bull. Inst. Math. Academia Sinica, **14**, 251-265, 1986.

Thakare, N.K. and Madhekar, H. C., Bull. Inst. Math. Academia Sinica, **12**, 211-215, 1987.

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A two non-identical priority unit system model with the effect of external causes and correlated failure and repair times

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Abstract : This paper presents the analysis of two non-identical units-1 and 2. Unit-1 gets priority in operation as well as in repair. Unit-1 stops working in any of the two ways : (i) When it fails totally (ii) when its operation come to standstill for some time due to an external cause. In case (ii) the unit-1 becomes down temporarily for some time and starts functioning again as soon as the external cause disappears. The system failure occurs only when both the units enter into total failure mode. The joint distribution of failure and repair times of unit-1 is taken to be bivariate of failure and repair times of unit-1 is taken to be bivariate exponential

Key Words : Priority unit system, correlated failure, repair times.

1. Introduction

No doubt that the two-unit standby redundant system models have been analysed very frequently in the field of reliability theory due to their vital application in day to day life. A large number of authors including (Agnihotri & Satsangi, 1996; Goel et al., 1996; Li Wei & Dinghusa Shi, 1993, 1994; Singh et al., 1991) investigated two priority/non priority unit reparable redundant system models under different sets of assumptions. The common assumption taken in all the above system models is that a unit breaks down only if it fails completely due to the occurrence of some fault in any of its element/completely. In many real life situations it can be observed that some units may also breakdown if an external cause affects its functioning. For example consider the two non-identical units in the system as an electric motor and a petrol engine which are used to draw underground water. Obviously, keeping the cost constraints in view the preference in operation will be given to electric motor over the petrol engines. But the electric motor which is being run by electricity may stop its operation if the power supply is cut off, and then the engine is put into operation. In this case the motor does not fail but its functioning comes to standstill for some time due to power supply failure (occurrence of an external cause). Further, if during the operation of petrol engine the electricity turns up again one will prefer electric motor over the petrol engine.

Keeping the above fact in view, we in the present paper analyse a two dissimilar unit cold standby system model in which the first unit is p (priority) and second is o (ordinary). The p-unit gets preference in both operation as well as repair over the o-unit. The p-unit can stop its functioning in two ways : first when it fails totally and secondly when some external cause arises which affects its operation and interrupts it functioning for some time but the p-unit does not fail and restarts its fuctioning as soon as the external cause is overcome. System failure occurs only when both the units fail totally. The joint distribution of failure and repair times of p-unit is taken to be bivariate exponential having the pdf-

$$f(x, y) = \theta\varphi\ (1\text{-}r)\ e^{-(\theta x-\ \varphi y)}\ I_0(2\sqrt{\theta\varphi\ rxy})$$

$$x,\ y,\ \theta,\varphi > 0\ ;\quad 0 < r < 1$$

The distribution of failure and repair times of o-unit and also that of appearance and disappearance of external cause are taken to be exponential with different parameters.

Using regenerative point technique the following important reliability characteristics of interest are obtained :

(i) Reliability and mean time to system failure (MTSF).
(ii) Pointwise and steady state availabilities of the system.
(iii) Expected up time of the system and expected busy period of the repairman during (0, t).
(iv) Expected number of repairs during (0,t).
(v) Net expected profit incurred by the system during (0,t) and in steady state.

ASSUMPTIONS

(1) System consists of two non-identical units, one being p-unit and other o-unit. The p-unit gets preference in both operation as well as repair over o-

unit.

(2) Initially p-unit is operative and 0-unit is kept cold standby.

(3) p-unit stops functioning in two ways (a) when it fails totally (b) when an external cause interrupts its operation for some time but it does not damage the unit.

(4) The joint distribution of failure and repair of p-unit is taken bivariate exponential whereas the distribution of the appearance and disappearance of external cause are taken negative exponential.

(5) A single repair facility is available to repair the failed unit.

(6) Switching device is perfect and instantaneous.

(7) The repaired unit works as good as new.

2. NOTATION AND STATES OF THE SYSTEM

X : r.v. denoting the life time of the first (p) unit.

Y : r.v. denoting the repair time of the first (p) unit.

θ : failure rate of first (p) unit.

φ : repair rate of first (p) unit.

β : failure rate of the second (o) unit.

α : rate of occurrence of external cause.

μ : rate of disappearance of external cause.

η : repair rate of second (o) unit.

p : probability of disappearance of external cause.

q : probability of appearance of external cause.

P_{ij} : unconditional steady-state probability of direct transition from regenerative state S_i to S_j.

$P_{ij}^{(m)}$: unconditional steady-state probability of transition from regenerative state S_i to S_j via non-regenerative state S_m.

$P_{ij} | x$: conditional steady-state probability of transition from regenerative state S_i to S_j given that the unit under repair in state S_i entered into F-mode after an operation of time x.

$P_{ij}^{(m)} | x$: conditional steady-state probability of transition from regenerative state S_i to S_j via non-regenerative state S_m given that the unit under repair in state S_i entered into

F-mode after an operation of time x.

ψi : unconditional mean sojourn time in state S_i.

$\psi_i|x$: conditional mean sojourn time in state S_i given that the unit under repair into F-mode after an operation of time x.

$g(x)$: marginal probability density function of X $= \theta\ (1-r)\ e^{-\theta(1-r)x},\ x > 0$

$k(y|x)$: conditional probability density function of $Y \mid X = x$ $= \varphi\ e^{-(\varphi y+\theta rx)} I_0 (2 \sqrt{\theta\varphi rxy}),\ \theta,\varphi,x,y > 0,\ 0 < r < 1$

$Z_i(t)$: probability that the system sojourns in state S_i upto time t.

$A_i(t)$: probability that the system is up at epoch t when it starts operation from regenerative state S_i.

$B_i(t)$: probability that the system is under repair when it initially starts from regenerative state S_i.

$V_i^p(t)$: expected number of repairs during (0, t) for p-unit

$V_i^o(t)$: expected number of repairs during (0, t) for p-unit

Symbols for the state of the system

N_0 : unit in normal mode and operative.

N_s : unit in standby state.

N_{ow} : unit waiting for operation.

F_r / F_w : unit in failure mode and under repair / waiting for repair.

Up States		Failed States
$S_0 \equiv (N_0,\ N_s)$,	$S_1 \equiv (N_{w0},\ N_0)$,	$S_3 \equiv (N_{wo},\ F_r)$
$S_2 \equiv (F_r,\ N_0)$,	$S_4 \equiv (N_0,\ F_r)$,	$\underline{S}_5 \equiv (F_r,\ F_w)$

The underlined state is non-regenerative. Transition diagram alongwith all transitions is shown in fig. - 1

3. TRANSITION PROBABILITIES AND SOJOUNRN TIMES

First we find the following steady-state conditional probabilities of transition-

$$P_{20} \mid x = p\ e^{-\beta u} dK\ (u \mid x) = pk^{*}(\beta \mid x) = \frac{\beta p}{\beta+\varphi}\, e^{-\frac{\theta\beta r x}{\beta+\varphi}}$$

$$P_{21} \mid x = q\ e^{-\beta u} dK\ (u \mid x) = qk^{*}(\beta \mid x) = \frac{\beta q}{\beta+\varphi}\, e^{-\frac{\theta\beta r x}{\beta+\varphi}}$$

$$P^{(5)}_{24} \mid x = \beta\ [\ \int e^{-\beta u} du \overline{K}\ (u \mid x)\ \ \{pdK(v|x)\} / K(\overline{u}|x)\}]$$

$$= p \int [\ \beta e^{-\beta u} du] dK\ (v \mid x) = p\ (1 - e^{-\beta v})\ dK\ (v \mid x)$$

$$= p[1 - k^{*}(\beta \mid x)] = p\ [\ 1 - \frac{\beta}{\beta+\varphi}\, e^{-\frac{\theta\beta r x}{\beta+\varphi}}\ ]$$

similarly,

$$P^{(5)}_{23} \mid x = q[1 - k^{*}(\beta \mid x)] = q\ [\ 1 - \frac{\beta}{\beta+\psi}\, e^{-\frac{\theta\beta r x}{\beta+\psi}}\ ]$$

so that,

$$p_{20 \mid x} + p_{21 \mid x} + p_{23}^{(5)}{}_{\mid x} + p_{24}^{(5)}{}_{\mid x} = 1$$

The other unconditional direct and indirect probabilities of transition are -

$p_{01} = [\ (\alpha) / (\alpha + \theta(1-r))],\quad p_{02} = [\ \theta(1 - r) / (\alpha + \theta(1-r))]$

So that

$p_{01} + p_{02} = 1$ (1)

Also

$p_{10} = [\mu / (\beta + \mu)] \qquad p_{13} = [\ \beta / (\beta + \mu)]$

and

$p_{10} + p_{13} = 1$ (2)

Similarly,

$p_{31} = [\eta / (\eta + \mu)], \qquad p_{34} = [\ \mu / (\eta + \mu)]$

so that,

$p_{31} + p_{34} = 1$ (3)

also,

$p_{40} = [\eta / (\alpha + \eta + \theta(1-r))],$

$p_{43} = [\alpha / (\alpha + \eta + \theta(1-r))],$

$p_{40} = [(\theta\ (1-r)) / (\alpha + \eta + \theta(1-r))]$

so that,

$p_{40} + p_{43} + p_{45} = 1$ (4)

again

$p_{53} = q, \; p_{54} = p$

so that

$$p_{53} + p_{54} = 1 \qquad (5)$$

$$p_{20} = p_{20 \mid x}\; y\,(x)\, dx$$

$$= [p\varphi \,/\, (\beta + \varphi)]\; \theta(1\text{-}r)e^{-\frac{\theta\beta r x}{\beta+\varphi}}\; dx = [p\psi\; (1\text{-}r)/(\beta+\psi(1\text{-}r))]$$

Similarly,

$$p_{21} = [q\varphi(1\text{-}r)/(\beta+\varphi(1\text{-}r))]$$

$$p_{24}^{(5)} = p \;\; p_{24}^{(5)}\; g(x)\; dx = [p\beta \,/\, (\beta+\varphi(1\text{-}r))]$$

$$p_{23}^{(5)} = [q\beta \,/\, (\beta+\varphi\; (1\text{-}r))]$$

so that

$$p_{20} + p_{21} + p_{23}^{(5)} + p_{24}^{(6)} = 1 \qquad (6)$$

Let X_i denotes the sojourn time in state S_i, then the mean sojourn time in state S_i is given by

$$\psi_i = P(X_i > t)\; dt$$

The mean sojourn times in various states are as follows -

$$\psi_0 = e^{-[\alpha+\theta(1-r)]u}\; du = [1 \,/\, (\alpha + \theta(1\text{-}r)] = \psi_4 \qquad (7)$$

$$\psi_1 = 1 \,/\, (\mu+\beta) \qquad (8)$$

$$\psi_3 = 1 \,/\, (\mu+\eta) \qquad (9)$$

$$\psi_{2 \mid x} = e^{-\beta u}\, K\; (u \mid x)\; dx \;=\; (1/\beta)[1\text{-}k^*(p \;\mid x)]$$

so that

$$\psi_2 = \psi_{2 \mid x}\; g(x)\; dx = (1/\beta)\; \theta(1\text{-}r)\; e^{-\theta(1-r)x}\; \left(1\text{-} \frac{\varphi}{\beta+\varphi} e^{-\frac{\theta\beta r x}{\beta+\varphi}}\right) dx$$

$$= 1 \,/\, [\; \beta+\varphi(1\text{-}r)] \qquad (10)$$

$$\psi_{5 \mid x} = \overline{K}(u \mid x) = (1 + \theta r x) \,/\, \varphi$$

$$\psi_5 = \psi_{5 \mid x}\; g(x)\; dx \;=\; 1/[\psi(1\text{-}r)] \qquad (11)$$

(The limits of integration are not mentioned whenever they are 0 to ∞)

4. Analysis of Results

(a) Reliability and MTSF

Let the r.v. T_i be the time to system failure when the system starts its operation from state $S_i \in E$, then the reliability of the system is given by

$$R_i(t) = P\ (T_i > t)$$

to determine $R_i(t)$, we assume the failed states (S_3, S_5) of the system as absorbing. Using the simple probabilistic arguments one can easily develop the recurrence relations among $R_i(t)$; $i = 0,1,2$. Taking the Laplace transforms of the relations and simplifying the resulting set of algebraic equations for $R^*_0(s)$, we get.

$$R_0^*(s) = \frac{Z_0^* + (q_{01}^* + q_{02}^* q_{21}^*)\ Z_1^* + q_{02}^* Z_2^*}{1 - q_{02}^* q_{20}^* - q_{10}^*\ (q_{01}^* + q_{02}^* q_{21}^*)} \qquad (12)$$

We have omitted the argument 's' for brevity, where Z_0^*, Z_1^* and Z_2^* are L.T. of

$$Z_0(t) = e^{-[\alpha+\theta(1-r)]t}$$

$$Z_1(t) = e^{-[\mu+\beta]t}$$

$$Z_2(t) = e^{-\beta t}\, \overline{K}\ (t|x)$$

Taking inverse L.T. of (12), we get the reliability of the system. MTSF is given by

$$E(T_0) = \lim_{s \to 0} R_0^*\ (s)$$

$$= \frac{\psi_0 + (p_{01} + p_{02}p_{21})\ \psi_1 + p_{02}\psi_2}{1 - p_{02}p_{20} - p_{10}(p_{01} + p_{02}p_{21})} \qquad (13)$$

(b) Availability

Let us define $A_i(t)$ as the probability that system is up at epoch t when it initially starts from state $S_i \in E$, Using of $A_i(t)$ and probabilistic concepts, the recurrence relations among $A_i(t)$ (i=0, 1, 2, 3, 4, 5) can easily be developed. Using the technique of L.T., the value of $A_0(t)$ in terms of its L.T. is as follows -

$$A^*_0(s) = N_2(s)\ /\ D_2(s) \qquad (14)$$

Where

$$\begin{aligned} N_2(s) = {} & Z^*_0\ [(1 - q^*_{45} q^*_{54})\ (1 - q^*_{13} q^*_{31}) - q^*_{34}(q^*_{43} + q^*_{45} q^*_{53})] \\ & + Z^*_1\ [(1 - q^*_{45} q^*_{54}) - q^*_{34}(q^*_{43} + q_{45} q^*_{53})]\ (q^*_{01} + q^*_{02} q^*_{21}) \end{aligned}$$

$$
\begin{aligned}
& - q^*_{01}q^*_{31}q^{*(5)}_{23}(1- q^*_{45}q^*_{54}) - q^*_{01}q^{*(5)}_{24}q^*_{31}\,(q^*_{43} + q^*_{45}q^*_{53})] \\
& + Z^*_2\, q^*_{02}[(1-q^*_{45}q^*_{54})\,(1- q^*_{13}q^*_{31})-q^*_{34}(q^*_{43} + q^*_{45}q^*_{53})] \\
& + Z^*_4\,[q^*_{01}q^*_{13}q^*_{34}+ q^*_{02}\{ q^{*(5)}_{24}+ q^{*(5)}_{23}\, q^*_{34})- q^*_{13}(q^*_{21}q^*_{34} + \\
& q^{*(5)}_{24}\, q^*_{31}\}]
\end{aligned} \tag{15}
$$

$$
\begin{aligned}
D_2(s) = \; & [(1-q^*_{45}q^*_{54})\,(1-q^*_{13}q^*_{31})-q^*_{34}(q^*_{43} +q^*_{45}q^*_{53})- q^*_{10}(q^*_{01} \\
& +q^*_{02}q^*_{21})] \\
& \times\,[(1-q^*_{45}q^*_{54})-q^*_{34}(q^*_{43} +q^*_{45}q^*_{53})]-q^*_{02}q^*_{10}q^*_{31}[q^{*(5)}_{23} \\
& (1-q^*_{45}q^*_{54}) \\
& + q^{*(5)}_{24}\,(q^*_{43}+q^*_{45}q^*_{53})- q^*_{02}q^*_{20}[(1-q^*_{45}q^*_{54})(1-q^*_{13}q^*_{31}) \\
& -q^*_{34}(q^*_{43}+q^*_{45}q^*_{53})]-q^*_{01}q^*_{13}q^*_{34}q^*_{40} -q^*_{02}q^*_{40}\,[q^*_{34}q^{*(5)}_{23} \\
& +q^{*(5)}_{24})+q^*_{13}(q^*_{21}\, q^*_{34}+q^*_{31}q^{*(5)}_{24}\,)]
\end{aligned} \tag{16}
$$

The steady state availability of the system is given by

$$
\begin{aligned}
A_0 &= \lim_{t \to \infty} A_0(t) \\
&= \lim_{s \to 0} sA^*_0(s) \\
&= N_2 / D_2
\end{aligned} \tag{17}
$$

Where,

$$
\begin{aligned}
N_2 = \; & [(1-p_{45}p_{54}) - p_{34}(p_{43} +p_{45}p_{53})]\,[\psi_0 + \psi_1(p_{01} +p_{02}p_{21})+\psi_2 p_{02}] \\
& + \psi_1 p_{01}p_{31}\,[p^{(5)}_{23}\,(1-p_{45}p_{54})+p^{(5)}_{24}\,(p_{43} +p_{45}p_{53}) \\
& + \psi_4[p_{01}p_{13}p_{34} +p_{02}\,(p^{(5)}_{23}\,p_{34}+p^{(5)}_{24} - p_{13}(\, p_{21}p_{34} + p^{(5)}_{24}\,p_{31})]
\end{aligned}
$$

and

$$
\begin{aligned}
D_2 = \; & p_{10}p_{13}\,(1- p_{45}p_{54}\,)\,[\psi_0 +p_{02}\,(\psi_2 +p_{25}\psi_5)] +p_{34}p_{40}\psi_0 +p_{02}p_{34}p_{40}(\psi_2 \\
& + p_{25}\psi_5\,)+\psi_3\,[(1-p_{45}p_{54})\{p_{13}\,(p_{01}+p_{02}p_{21})+p_{02}(p^{(5)}_{23}+p^{(5)}_{24})\} \\
& - p_{02}p^{(5)}_{24}p_{40}.] + \psi_4\,[p_{01}p_{13}p_{34} +p_{02}(p^{(5)}_{23}p_{34} + p^{(5)}_{24}) \\
& + p_{13}(p_{21}p_{34}+p_{31}p^{(5)}_{24}\,))]+\psi_5\,[p_{45}(1-p_{13}p_{31}\,)(1-p_{02}p_{20}) \\
& - \; p_{10}\,(p_{01}+p_{02}(p_{21}+p_{31}p^{(5)}_{23})\}
\end{aligned}
$$

The expected up time of the system during (0, t) is given by

$$
\mu_{up}(t) = \int_0^t A_0(u)du
$$

so that

$$\mu^*_{up}(s) = A^*_0(s)/s \qquad (18)$$

(c) Busy Period Analysis

We define $B_i(t)$ as the probability that repairman is busy in the repair of the failed unit when system initially starts from state $S_i \in E$. Using simple probabilistic arguments, the value of $B_0(t)$ can easily be obtained in terms of its L.T. as follows :-

$$B^*_0(s) = N_3(s)\ /D_2(s) \qquad (19)$$

Where

$$\begin{aligned} N_3(s) = {} & Z^*_2 q^*_{02}[(1-q^*_{45}q^*_{54})\ (1-q^*_{13}q^*_{31})-\ q^*_{34}(q^*_{43} + q_{45}q^*_{53})] \\ & + Z^*_3[(1-q^*_{45}q^*_{54})\{q^*_{13}(q^*_{10} + q^*_{02}q^*_{21}) + q^*_{02}q^{(5)}_{23}\} \\ & + q^*_{02}\{q^{*(5)}_{24}(q^*_{43}+q^*_{45}q^*_{53})-\ q^*_{25}(q^*_{53}+q^*_{43}\ q^*_{54}\}] + Z^*_4[q^*_{01}q^*_{13}q^*_{34} \\ & + q^*_{02}\{\ q^{*(5)}_{24} + q^{*(5)}_{23}\ q^*_{34}) + q^*_{25}\ (q^*_{54} + q^*_{34}q^*_{53}) + q^*_{13}(q^*_{21}q^*_{34} \\ & + q^*_{31}q^{*(5)}_{24}\ )] + Z^*_5\ [q^*_{01}q^*_{13}q^*_{34}q^*_{45} + q^*_{02}q^*_{45}\ (q^{*(5)}_{24} + q^{*(5)}_{23} \\ & q^*_{34}) + q^*_{13}q^*_{21}q^*_{34}\ ) + q^*_{02}\{q^*_{25}(1-q^*_{43}q^*_{34}) + q^*_{13}q^*_{31} \\ & (q^*_{25}+q^{*(5)}_{24}q^*_{45}\ \}] \end{aligned}$$

In the long run, the probability that the repairman is busy is given by

$B_0=N_3\ /\ N_2$

Where

$$\begin{aligned} N_3 = {} & p_{02}(\psi_2 + p_{25}\psi_5\ )\ [(1-p_{45}p_{54})(1-p_{13}p_{31})-\ p_{34}\ (p_{43} + p_{45}p_{53})] \\ & + \psi_3[1 - p_{45}\ p_{54}\ )(p_{01}p_{13}+p_{02}p_{13}p_{21}+p_{02}p^{(5)}_{23}) + p_{02}p^{(5)}_{24}(p_{43} + p_{45}p_{53})] \\ & + (\psi_4 + p_{45}\psi_5\ )\ [p_{21}p_{34}+p_{31}p^{(5)}_{24})p_{02}p_{13}+p_{01}p_{13}p_{34}+p_{02(}p^{(5)}_{24}+p_{34} \\ & p^{(5)}_{23})] \end{aligned}$$

The expected busy period of the repairman during (0, t) is given by

$$\mu_b(t) = \int_0^t B_0(u)du$$

so that

$$\mu^*_b(s) = B^*_0(s)/s \qquad (20)$$

(d) Expected number of repairs

For p-unit

Let us define $V_i^p(t)$ as the expected number of repairs of p-unit during (0, t) when system initially starts from regenerative state S_i, Using the definition of $V_i^p(t)$ and basic probabilistic reasonings, the recurrence relations among $V_i^p(t)$

(i=0,1,2,3,4,5) can be developed and using the technique of L.S.T. the value of $\widetilde{V}_0^p(t)$ can be obtained as follows -

$$\widetilde{V}_0^p(s) = \{N_4(s)\} \,/\, \{D_4(s)\} \qquad (21)$$

Where

$$\begin{aligned} N_4(s) \;=\; & \widetilde{Q}_{02}(\widetilde{Q}_{20}+\widetilde{Q}_{21}+Q^{(5)}{}_{23}+Q^{(5)}{}_{24}\ [(1-\widetilde{Q}_{45}\widetilde{Q}_{54})(1-\widetilde{Q}_{13}\widetilde{Q}_{31}) \\ & - \widetilde{Q}_{34}(\widetilde{Q}_{43}+\widetilde{Q}_{45}\widetilde{Q}_{53})]+\widetilde{Q}_{45}(\widetilde{Q}_{53}+\widetilde{Q}_{54})[\widetilde{Q}_{10}\widetilde{Q}_{13}\widetilde{Q}_{23} \\ & + \widetilde{Q}_{02}\{\widetilde{Q}^{(5)}{}_{24}+\widetilde{Q}^{(5)}{}_{23}\widetilde{Q}_{34})+\widetilde{Q}_{13}(\widetilde{Q}_{21}\widetilde{Q}_{34}+\widetilde{Q}_{31}\widetilde{Q}^{(5)}{}_{24})\}] \end{aligned}$$

and $D_4(s)$ can be written on replacing q_{ij}^* and $q_{ij}^{(k)*}$ by $\widetilde{Q}_{ij}$ and $\widetilde{Q}_{ij}^{(k)}$ in (16)

In steady state the expected number of repairs per unit time is given by

$$\begin{aligned} V_0^p &= \lim_{t \to \infty} [V_0^p(t)/t] \\ &= \lim_{s \to 0} s^2\, V_0^p(s) \\ &= N_4 \,/\, D_3 \qquad (22) \end{aligned}$$

Where,

$$\begin{aligned} N_4 = \; & p_{02}[(1-p_{45}p_{54})(1-p_{13}p_{31})-p_{34}(p_{43}+p_{45}p_{53})] \\ & +p_{45}\{p_{02}(p_{23}{}^{(5)}p_{34}+p_{24}{}^{(5)})+p_{13}(p_{21}p_{34}+p_{31}p_{24}{}^{(5)})\}]+p_{01}p_{13}p_{23}p_{45} \end{aligned}$$

for o-unit

Similarly defining $V_i^p(t)$ as the expected number of repairs for o-unit during (0,t) when system initially starts from $S_i \in E$. Using the definition of $V_i^o(t)$ and basic probabilistic reasonings, the recurrence relations among $V_i^o(t)$, (i=0,1,2,3,4,5) can be developed and using the technique of L.S.T., the value of $\widetilde{V}_0^o(s)$ can be obtained as follows -

$$\widetilde{V}_0^o(s) = N_5(s) \,/\, D_4(s) \qquad (23)$$

$$N_5(s) = \tilde{Q}_{01}\tilde{Q}_{13}(\tilde{Q}_{31}(1-\tilde{Q}_{45}\tilde{Q}_{54})+\tilde{Q}_{34}\tilde{Q}_{40}]+\tilde{Q}_{02}\tilde{Q}^{(5)}{}_{23}[\tilde{Q}_{31}(1-\tilde{Q}_{45}\tilde{Q}_{54})$$
$$+\tilde{Q}^{(5)}{}_{24}(\tilde{Q}_{43}+\tilde{Q}_{53}\tilde{Q}_{45})]+\ \tilde{Q}_{02}\tilde{Q}_{40}(\tilde{Q}_{24}{}^{(5)}+\tilde{Q}_{34}\tilde{Q}_{23}{}^{(5)})$$

In steady state, the expected number of repairs for o-unit per unit time is given by

$$V_0^{\circ} = \lim_{t \to \infty} [V_0^{\circ}(t)/t]$$

$$= \lim_{s \to 0} s^2\ V_0^{\circ *}(s)$$

$$= \lim_{s \to 0} s\ \tilde{V}_0(s) \qquad (22)$$

Where

$$N_5 = \quad p_{01}p_{13}\,[p_{31}\ (1-p_{45}p_{54})+p_{34}\ p_{40}\ ]+p_{02}p^{(5)}{}_{23}[p_{31}\ (1-p_{45}p_{54})$$
$$+\ p_{24}{}^{(5)}\ (p_{43}+p_{53}\ p_{45})]+p_{02}p_{40}(p^{(5)}{}_{24}+p^{(5)}{}_{23}p_{34})$$

5. Profit Function Analysis

Two profit funcitons $P_1(t)$ and $P_2(t)$ can be found easily for the system model under study with the help of the characteristics obtained earlier. The expected total profits incurred during (0, t) are

$P_1(t)$ = expected revenue in (0,t) - Expected total expenditure during (0,t).

$$= K_0\mu_{up}(t)\ -\ K_1\mu_b(t) \qquad (24)$$

and

$$P_2(t) = K_0\mu_{up}(t)\ -\ K_2V_0{}^{p}(t)\ -\ K_3\ V^{\circ}{}_0(t) \qquad (25)$$

where K_0 is the revenue per unit up time and K_1 is the cost per unit time for which the repairman is busy in the repair of failed unit. K_2 and K_3 are the per unit repair cost of priority and ordinary unit respectively.

The expected profits per unit time in steady state are given by

$$P_1 = \lim_{\in \to \infty} (P_1(t)/t) = K_0A_0\text{-}K_1B_0 \qquad (24)$$

and

$$P_2 = \lim_{\in \to \infty} (P_2(t)/t) = K_0A_0\ -\ K_2V_0{}^{p}\text{-}K_3V^{\circ}{}_0 \qquad (25)$$

6. Graphical Study of the System Model

For a more concrete study of the system and to observe the effect of correlation and failure parameter θ on MTSF and both the profit functions, we plot these characteristics w.r.t. θ for different values of correlation coefficient r (=0.25, 0.50, 0.75) keeping the other parameters fixed ($\alpha = 0.004 = \beta$, $\varphi = 0.006 = \mu$, $\eta = 0.008$. p= 0.50 = q).

Fig. 2 reveals the behaviour of MTSF w.r.t. θ for r = 0.25, 0.50 and 0.75 when other parameters are fixed. The fig. shows that MTSF decreases uniformly with the increase in the failure rate θ for each value of correlation coefficient r. We also observe that MTSF is higher for higher value of r, which means that for higher value of r the repair facility has a better understanding of the failure phenomenon resulting in more life time of the system.

If fig.3 smooth and dotted curve represent respectively graphs for profit functions P_1 and P_2 w.r.t. θ for varying range of r (=0.25, 0.50, 0.75). From the graphs it is observed that profit funcitons P_1 and P_2 decrease with the increase in failure parameter θ and increase with the increase in correlation coefficient r. It is observed that profit function P_2 is always higher as compared to P_1. Thus we conclude that better understanding of failure pohenomenon by the repairman results in better system performance.

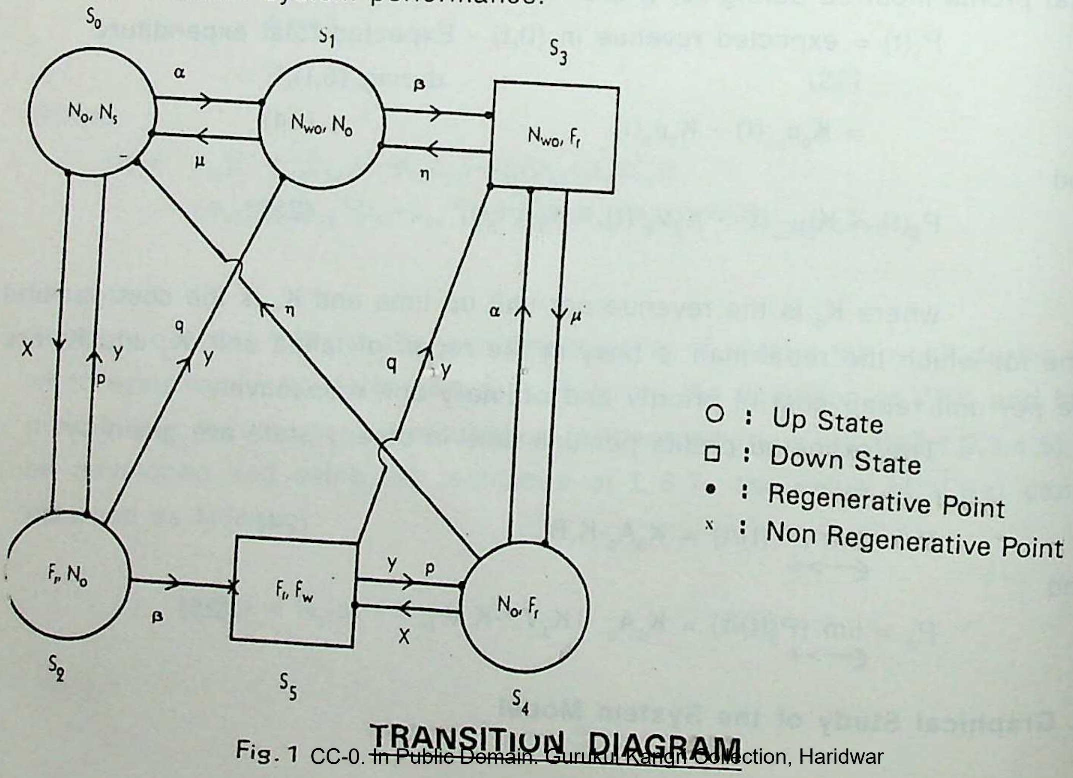
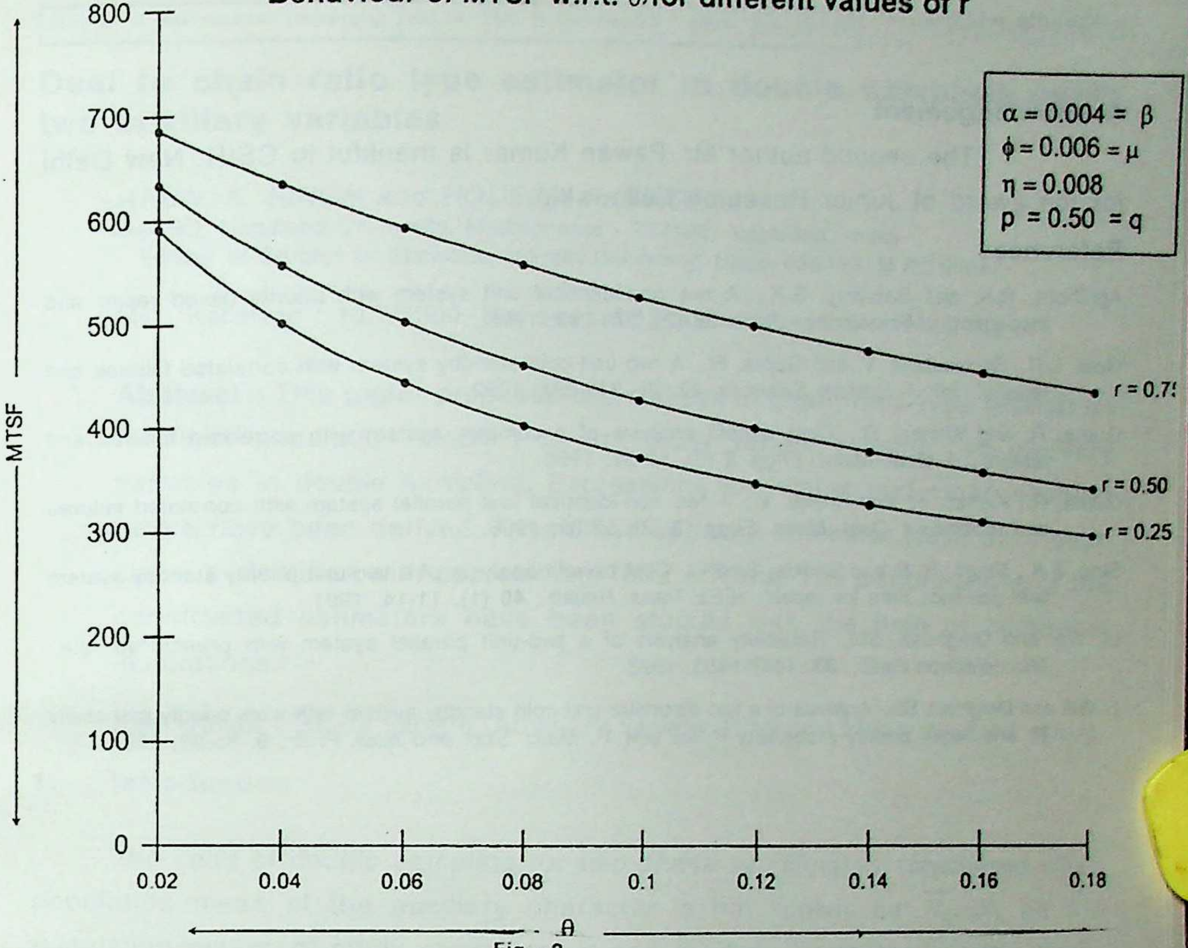
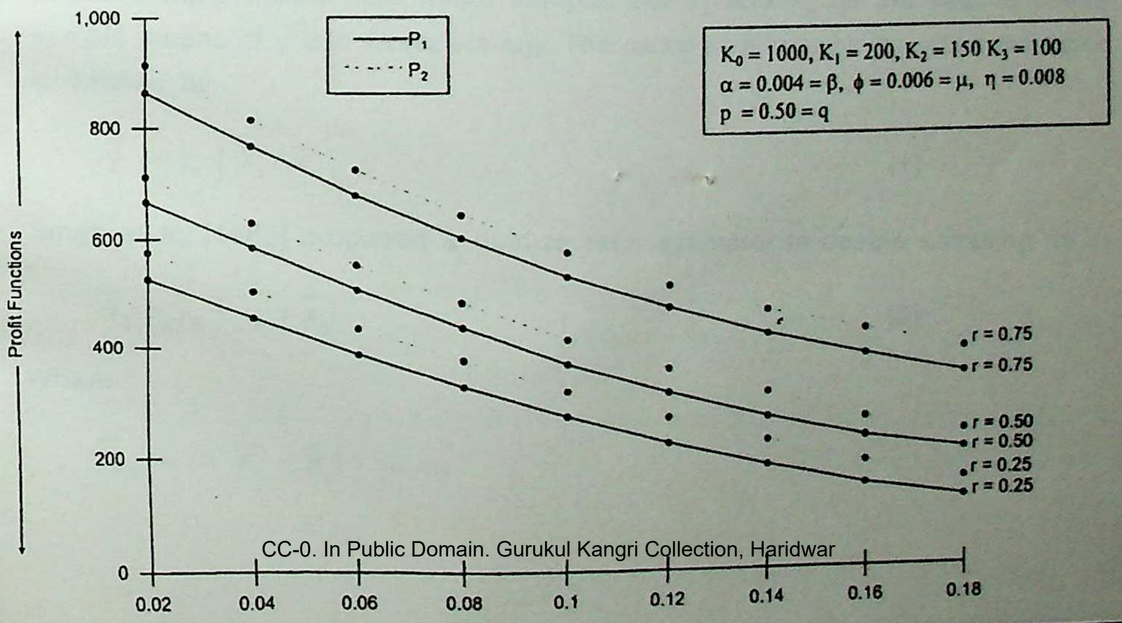


Fig. 1 TRANSITION DIAGRAM



Behaviour of MTSF w.r.t. θ for different values of r

Fig. - 2



Comparison of profits P_1 and P_2 w.r.t. θ for different values of r

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References

Agnihotri, R.K. and Satsangi, S.K., 'A two non-identical unit system with priority based repair and inspection', *Microelectron Relib.* **36** (2), 279-282, 1996.

Goel, L.R., Shrivastava, P. and Gupta, R., 'A two unit cold standby system with correlated failures and repairs', *Int. J. System Sciences,* **23** (3), 379-391, 1992.

Gupta, R. and Kishan, R., 'Cost benefit analysis of a complex system with correlated failures and repairs', *J. Qual. Maint. Engg.* **2** (2), 52-59, 1996.

Gupta, R., Kishan, R. and Kumar, P., 'A two non-identical unit parallel system with correlated failures and repairs', *J. Qual. Maint. Engg.*, **2** (2), 52-59, 1996.

Sing, S.K., Singh, R. P. and Shukla, Sindhu, 'Cost benefit analysis of a two-unit priority standby system with patience time for repair', *IEEE Trans. Reliab.*, **40** (1), 11-14, 1991.

Li, Wei and Dinghusa, Shi, 'Reliability analysis of a two-unit parallel system with preemptive rule', *Microelectron Relib.*, **33**, 1447-1453, 1993.

Li Wei and Dinghusa Shi, 'Analysis of a two dissimilar unit cold standby system with work priority probability P_1 and repair priority probability P_2 for unit 1', *Math. Stat. and Appl. Prob.*, **9**, 85-98, 1994.

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Dual to chain ratio type estimator in double sampling using two auxiliary variables

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Abstract : This paper proposes two classes of chain ratio-type estimators for finite population mean $\overline{Y}$ of the study variate y using two auxiliary variables in double sampling. Expressions for biases and mean squared errors have been derived. Asymptotic optimum estimator (AOE"s) in each class is identified with approximate MSE formula. The performances of the constructed estimators have been studied with the help of numerical illustrations.

Key words : Study variate, Auxiliary variate, Bias and Mean squared errors.

1. Introduction

The case of double sampling (or two phase sampling) is considered when population mean of the auxiliary character is not known. Let $\overline{Y}_n$, $\overline{X}_n$ be the population means of study characters y and auxiliary character x respectively. Let $\overline{X}_n$' be the mean of x for initial sample size n,' (n<n') be the size of second phase sample drown from initial sample. Let $\overline{Y}_n$ and $\overline{X}_n$ be the second phase sample means of y and x respectively. The usual double sampling ration-estimator is defined by

$$\overline{y}_1 = \overline{y}_n \left(\overline{x}_n / \overline{x}_n \right) \quad (1)$$

Singh et al. [1985] proposed a dual to ratio estimator in double sampling as

$$\overline{y}_2 = \overline{y}_n \left(\overline{x}_{no}' / \overline{x}_n \right) \quad (2)$$

Where

$$\overline{x}_{no}' = (n' \overline{x}_n' - \overline{x}_n) / (n'-n)$$

is the mean of auxiliary character x for the remaining no'=(n'-n) units in the initial sample.

If $\overline{X}n$ is not known, but $\overline{Z}n$, the population mean of another auxiliary variable z which is observable inexpensively, closely related to x but compared fo x remotely related to y (i.e.pyx>Pyz, Pyx and Pyz being the correlation coefficients between (y,x) and (y,z) is available. In this case Chand (1975) defined the chain ratio estimator for Y as

$$y3 = yn\ (xn/xn)\ (Zn/zn) \qquad (3)$$

Where, $\overline{Z}n'$ denote the sample mean based on n' (>n) units of the auxiliary variable z.

In this paper two classes of chain ratio-type estimators are proposed using another auxiliary variable z when the population mean of the main auxiliary variable x is not known. Expressions for biases and mean equare errors have been derived to the first degree of approximation and comparisons are made with some other estimators. Two numerical examples are given to support the findings.

2. SUGGESTED CLASSES OF ESTIMATORS AND THEIR PROPERTIES

We suggest the following classes of estimators for population mean $\overline{Y}$ as

$$d_1=\overline{y}_n\ (\overline{x}'_n/\overline{x}_n)\ \overline{z}'_{no}/\overline{Z}_N)^{\alpha} \qquad (4)$$

$$d_2=\overline{Y}_n(\overline{X}'_{no}/\overline{X}'_n)^{\alpha 1}\ (\overline{z}'_{no}/\overline{z}'_n)^{\alpha 2} \qquad (5)$$

Where α, α1 and α2 are suitably chosen constants,

$\overline{z}'_{no} = (N\overline{Z}_n - n\overline{z}_n)\ (N-n')$ is the mean of the z character for the remaining n'o= (N-n') units in the sample and $\overline{x}_{no}$ is same as defined earlier.

To the first degree of approximation, the mean squared errors of d_1 and d_2 are respectively given by

$$\text{MSE }(d_1) = \bar{Y}n^2\ [\theta Cy^2+K_1C^2x(1-2C)+\theta'\alpha g(\alpha g-2C^*)\ Cz^2] \quad (6)$$

$$\text{MSE }(d_2) = \bar{Y}n^2(\theta Cy^2+K_1\alpha_1 Cx^2(\alpha_1 K-2C)$$

$$+\alpha_2(1+g)\theta' Cz^2\{(1+g)\ \alpha_2-2C^*\}] \quad (7)$$

Where $\theta=(1-f_1f_2)/n,\ \theta'=(1-f_1)/n', K1=(\theta-\theta')=(1-f_2)/n,$
$K=f_2/(1-f_2),\ g=f_1/(1-f_1),\ f_1=n'/N, f_2=n/n'$
$C=p_{yx}Cy/Cx$ and $C^*=p_{yz}Cy/Cz$

The MSE (d_1) at (6) is minimized for

$$\alpha=C^*/g)=\alpha_{opt}\ \text{(say)} \quad (8)$$

Substitution of (8) in (6) yields the minimum MSE of d_1 as

$$\text{min.MSE }(d1)=\bar{Y}_N^2\ [\theta C_y^2+K_1C_x^2(1-2C)-\theta' C^{*2}C_z^2] \quad (9)$$

Further the MSE (d_2) at (7) is minimum when

$$\alpha_1=(C/K)$$

$$\alpha_2=C^*/(1+g) \quad (10)$$

Thus the resulting (minimum) MSE of d_2 is given by

$$\text{min.MSE }(d_2)=\bar{Y}_N^2[\theta C_y^2-K_1C^2C_x^2-\theta' C^{*2}C_z^2] \quad (11)$$

3. EFFICIENCY COMPARISONS

We write the MSE of Sukhatme's [1997] estimator $\bar{y}_3$ upto terms of order n^{-1}, as

$$\text{MSE }(\bar{y}_3) = \bar{Y}n^2[\theta Cy^2+K_1Cx^2(1-2C)+\theta'(1-2C^*)C_z2] \quad (12)$$

From (9) and (12) we have

$$\text{MSE }(\bar{y}_3)-\text{minMSE }(d_1) = \bar{Y}N^2\theta'(1-C^*)^2\ Cz^2$$

$$>0 \quad (13)$$

Which implies that

$$\text{min. MSE }(d_1) \leq \text{MSE }(\bar{y}_3) \quad (14)$$

This shows that the proposed class of estimators d_1 is more effcient than Chand's Chain ratio estimator $\bar{y}_3$

Next, from (9) and (11), we have

$$\text{min MSE }(d_1)-\text{min.MSE }(d_2) = \bar{Y}N^2\ K_1C_2Cx^2 \geq 0 \quad (15)$$

i.e. $\text{min.MSE}(d_2)<\text{min. MSE }(d_1)$ (16)

which proves that the suggested class of estimators d_2 is more efficient than d_1.

Form (14) and (15) we have the following inequality

$$\text{min.MSE}(d_2) \leq \text{min. MSE } (d_1) \leq \text{MSE } (\overline{y}_3) \tag{17}$$

which follows that the estimator d_2 is more efficent than d_1 and $\overline{y}_3$.

for $\alpha = 1$, d_1 reduces to the estimator.

$$\overline{y}_4 = \overline{y}_n(\overline{x}'_n/\overline{x}_n)\ (\overline{z}'_n/\overline{Z}_n) \tag{18}$$

whose MSE to the first degree of approximation is given by

$$\text{MSE } (\overline{y}_4) = \overline{Y}_N^2[\theta C_y^2 + K_1 C_x^2(1-2C) + \theta' q' C_z^2(g-2C^{*})] \tag{19}$$

The expressions for MSE's of the estimators $\overline{y}$, $\overline{y}_1$ and $\overline{y}_2$ upto terms of order n^{-1} age given as follows.

$$\text{MSE } (\overline{y}) = \overline{Y}_N^2\, \theta C y^2 \tag{20}$$

$$\text{MSE } (\overline{y}_1) = \overline{Y}_N^2\ [\theta C_y^2 + K_1 C_x^2(1-2C)], \tag{21}$$

$$\text{MSE } (\overline{y}_2) = \overline{Y}_N^2[\theta C_y^2 + K\ K1 C_x^2(K-2C)] \tag{22}$$

Now we give the conditions under which the estimator $\overline{y}_4$ is more efficinet than estimators $\overline{y}, \overline{y}_1, \overline{y}_2$ and $\overline{y}_3$ respectively.

(i) The MSE $(\overline{y}_4) <$ MSE $(\overline{y})$ if
$C > (1/2)$ and $C^* > (g/2)$

(ii) The MSE $(\overline{y}_4) <$ MSE $(\overline{y}_1)$ if
$C^* > (g/2)$

(iii) The MSE $(\overline{y}_4) <$ MSE $(\overline{y}_2)$ if
either $C > (1+K)/2$ (when $n < n'/2$) and $C^* > g/2$
or $C < (1+K)/2$ (when $n > n'/2$) and $C^* > g/2$

(iv) The MSE $(\overline{y}_4) <$ MSE $(\overline{y}_3)$ if
either $C^* < 1/2$, when $n' < N/2$
or $C^* > 1$, when $n' > N/2$

When the value of α in the estimator d_1 at (4) does not conicide with its exact optimum value, then we find the regions in which d_1 is more efficient than $\overline{y}$, $\overline{y}_1$, $\overline{y}_2$, $\overline{y}_3$ and $\overline{y}_4$

(i) The estimator d_1 will dominate the estimator $\overline{y}$ if
MSE $(d_1) <$ MSE $(\overline{y})$
i.e. either $0 < \alpha < (2C^*/g)$; $C > 1/2$
or $(2C^*/g) < \alpha < 0$; $C > 1/2$

(ii) The estimator d_1 is more efficient than $\overline{y}_1$ if
either $0<\alpha<(2C^*/g)$
or $(2C^*/g)<\alpha<0$

(iii) The MSE of d_1 does not exceed the MSE of $\overline{y}_2$ if
either $0<\alpha<(2C^*/g)$, and $C>(1-K)/2$.
Or $g < \alpha <0$, and $C>(1-K)/2$.

(iv) The estimator d_1 is more precise than $\overline{y}_3$ if
either $-(1/g) < \alpha < (1+2C^*)/g$
or $-(1+2C^*)/g < \alpha < -(1/g)$

(v) The estimator d_1 beats the estimator $\overline{y}_4$ if
either $1 < \alpha < (2C^*/g)-1$
or $(2C^*/g)-1 < \alpha < 1$

Thus we oberve that for the above values of C, C^* and α in specified ranges of K and g, the proposed estimators y_4 and d_1 will always be more efficient than the estimators $\overline{y}$, $\overline{y}_1$, $\overline{y}_2$ and $\overline{y}_3$.

It is to be noted that a large number of estimators for the class of estimators d_2 can be generated for different suitable choices of $\alpha 1$ and $\alpha 2$ and their superiority can be discussed as in case of d_1.

4. NUMERICAL ILLUSTRATION

For the purpose of numberical illustration, we consider the data earlier used by Sukhatme and Chand (1977)

$\overline{Y}_N=0.293458 \times 10^4$, $P_{yx}=0.93$, $Cy^2=4.02004$

$\overline{X}_N=0.103182 \times 10^4$, $P_{yx}=0.84$, $Cy^2=2.5528$

$\overline{Z}_N=0.365149 \times 10^4$, $P_{xz}=0.77$, $Cz^2=2.09379$

$\overline{N}=120$.

y: bushels of apples harvested in 1964.

x: apple trees of bearing age in 1964.

z: bushels of apples harvested in 1959.

For different values of f_1 and f_2, we have computed the relative efficiencies of various estimators of $\overline{Y}$ with respect to usual unbiased estimator $\overline{y}$ and displayed in table 1.

Table-1: Relative efficiency (%) of various estimators of y with respect to y.

Estimator	f_2 \ f_1	0.05	0.10	0.20	0.30	0.40	0.50	0.60
$\bar{y}$		100.00	100.00	100.00	100.00	100.00	100.00	100.00
$\bar{y}_1$		517.69	523.19	534.62	546.68	559.42	572.92	587.24
$\bar{y}_2$		107.83	107.85	107.89	107.94	107.98	108.02	108.07
$\bar{y}_3$	0.05	624.11	625.56	628.51	631.52	634.58	637.71	64.91
$\bar{y}_4$		625.78	539.56	567.79	595.74	620.74	637.71	637.13
d_1		626.71	628.05	630.75	633.51	636.31	639.18	642.09
d_2		700.84	702.72	706.53	710.43	714.40	718.47	722.62
$\bar{y}$		100.00	100.00	100.00	100.00	100.00	100.00	100.00
$\bar{y}_1$		427.88	435.09	450.49	467.38	485.98	506.56	529.46
$\bar{y}_2$		116.53	116.63	116.83	117.03	117.24	117.45	117.67
$\bar{y}_3$	0.10	596.39	598.93	604.15	609.58	615.22	621.08	627.19
$\bar{y}_4$		435.07	458.35	500.27	545.36	589.21	621.08	619.77
d_1		601.18	603.53	608.35	613.35	618.55	623.94	629.58
d_2		665.29	668.53	675.20	682.15	689.39	696.94	704.83
$\bar{y}$		100.00	100.00	100.00	100.00	100.00	100.00	100.00
$\bar{y}_1$		317.05	324.23	340.12	358.43	379.76	404.94	435.09
$\bar{y}_2$		136.49	137.00	138.07	139.20	140.39	141.66	143.02
$\bar{y}_3$	0.20	549.41	551.28	559.43	568.21	577.66	587.86	598.93
$\bar{y}_4$		329.55	351.05	401.73	463.27	531.67	587.86	594.66
d_1		555.58	559.21	566.84	575.02	583.81	593.29	603.53
d_2		603.59	608.42	618.62	629.62	641.53	654.45	668.53

Estimator	f_2 \ f_1	0.05	0.10	0.20	0.30	0.40	0.50	0.60
$\bar{y}$		100.00	100.00	100.00	100.00	100.00	100.00	100.00
$\bar{y}_1$		251.29	257.31	270.91	287.09	306.65	330.77	361.27
$\bar{y}_2$		158.36	159.81	162.92	166.37	170.22	174.54	179.44
$\bar{y}_3$	0.30	505.47	509.88	529.37	529.88	541.58	554.71	569.51
$\bar{y}_4$		263.23	283.35	333.28	399.22	480.48	534.71	549.00
d_1		516.03	520.21	529.19	539.10	550.11	562.41	576.24
d_2		551.90	557.29	568.92	581.86	596.36	612.70	631.26
$\bar{y}$		100.00	100.00	100.00	100.00	100.00	100.00	100.00
$\bar{y}_1$		207.76	212.53	223.47	236.75	253.25	274.26	301.95
$\bar{y}_2$		176.11	178.95	185.31	192.79	201.70	212.51	225.88
$\bar{y}_3$	0.40	469.16	473.57	483.25	494.26	506.92	521.61	538.87
$\bar{y}_4$		218.75	236.74	282.98	347.85	434.65	521.62	512.79
d_1		481.42	485.64	494.89	505.38	517.41	513.30	547.56
d_2		507.95	513.25	524.91	538.25	553.66	571.67	592.99
$\bar{y}$		100.00	100.00	100.00	100.00	100.00	100.00	100.00
$\bar{y}_1$		176.82	180.47	188.91	199.34	212.53	229.77	253.25
$\bar{y}_2$		176.82	180.47	188.91	199.34	212.53	229.77	253.25
$\bar{y}_3$	0.50	437.42	441.47	450.52	461.08	473.57	488.57	506.92
$\bar{y}_4$		186.86	202.69	244.44	305.73	393.38	488.57	476.01
d_1		450.87	454.78	463.51	473.67	485.64	499.96	517.40
d_2		470.13	474.93	485.67	498.27	513.25	531.35	553.66
$\bar{y}$		100.00	100.00	100.00	100.00	100.00	100.00	100.00
$\bar{y}_1$		153.69	156.37	162.62	170.43	180.47	193.84	212.53
$\bar{y}_2$		148.73	151.07	156.53	163.28	171.87	183.15	198.63
$\bar{y}_3$	0.60	409.43	412.89	420.73	430.09	441.47	455.59	473.57
$\bar{y}_4$		162.87	176.74	3213.98	270.57	356.01	455.99	438.65
d_1		423.69	427.07	434.69	443.78	454.78	468.39	485.64
d_2		437.24	441.28	450.46	461.48	474.93	491.71	513.25

5. Conclusions

Table-1 exhibits that the relative efficiencies of the estimators $\overline{yj}$(j=1 to 4), d_1 and d_2 as f_1 increases; while it decreases as f_2 increases except in the case of the estimator $\overline{y}_2$. The estimators d_1 and d_2 are always better than the estimators $\overline{y}$ and $\overline{yj}$(j=1 to 4) with substantial gain in efficiency. The largest gain in efficiency is seen at $(f_1, f_2) = (0.05, 0.05)$. Thus the use of estimators is recommended when the budget is limited. The suggested estimators d_1 and d_2 are to be preferred over $\overline{y}$ and $\overline{yj}$ (j=1 to 4).

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References

Chand, L., Some ratio-type estimators based on two or more auxiliary variables, Unpublished Ph.D dissertaion, Lowa State University, Ames, Lowa, 1975.

Kiregyera, B., A Chain ratio type estimator in finite population double sampling using two auxiliary variables. Metrika, **27**, 217-223, 1980.

Singh, M., Chaubey, Y.P. and Dwivedi, T.D., On a dual to ratio estimator in double sampling Journal of Organizational Behaviour and Statistics. **2** (1), 131-139, 1985.

Srivenkataramana, T., A dual to ratio estimator in sample survey. Biometrika, **67** (1) 199-204 1980.

Sukhatme, B.V. and Chand, L., Multivariate ratio-type estimators, Proc. Social Statistics Section American Statistical Association, 927-931, 1977.

Sukhatme, P. V. and Sukhatme, B.V., Sampling theory of surveys with application, Lowa State University Press, Ames, Lowa, USA and Indian Society of Agricultural Statistics, New Delhi, India, Second Revised Edition, 1977.

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hikari, D. and Majumder, S.K., Pramana, 14, 35-40, 1980.

ner, E.A. and Skobov, V.G., 'Plasma effects in metals', Taylor and Francis, 1971.

vis, B.S., Hope, R.D. and Tyan, A.B., Advances in Biology, ed R.M. Field, New York Academic ss, P 48, 1970.

arma, S.K., Photoconductivity of some semiconducting compounds, Ph. D. Thesis, Ravishankar versity, Raipur, 1990.

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